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A COMBINED GARBAGE DISPOSAL AND ELECTRIC lighting plant is under construction for the Shoreditch vestry of London, England. The most interesting features of the plant are: The combination of steam generation for the electric works with refuse destruction; the use of the Druit Halpin's system of thermal storage for the boiler feed, and the employment of electric motors for handling the garbage in and about the works. The plant was formally opened a few weeks ago by Lord Kelvin, but will not be completed for some time. The station is located in the center of the district served, close by public baths and wash-houses. There will be twelve garbage furnaces and six boilers, furnished and erected by Manlove, Alliott & Co.; a Halpin thermal storage cylinder 8 ft. in diameter and 35 ft. long. At the start the electric generating plant will include six generators direct-connected to Willans engines, three of the generators having a capacity each of 160 K-W. at 1,100 volts, and the other three 70 K-W. at 165 volts. An underground system will be used, and for the present 57 street arc lamps will be furnished, each to be supplanted at midnight by two 32-c. p. incandescent lamps. There will also be 36 incandescent lamps in side streets burning all night. The arc lamps will use 12½ amperes at 45 volts, and will be arranged in three circuits of 19 in series. Each of the twelve garbage furnaces is rated at a daily capacity of 8 to 12 tons. The boilers are mounted above and between the furnaces, one boiler between two furnaces, arranged to be fired independently. The electrical work is being done by the Electric Construction Co. Mr. E. Manville, of Kincaid, Waller & Manville, is consulting engineer. We are indebted to "The Electrician," of London, for the above information.

THE DRAINAGE OF THE HAZLETON COAL BASIN, in Pennsylvania, has been planned by the Lehigh Valley Coal Company, says the Hazleton "Sentinel." Work was quietly commenced 14 months ago, and a slope is now sunk on the Wharton vein, 1,100 ft. long. A steam pipe line leads down to two large chambers cut at the bottom of the slope, and in these two pumps are now being erected, with a capacity of 5,000,000 gallons daily each. Two lines of 16-in. pipe will carry the water up the slope. From the bottom of this slope a tunnel was driven 250 ft. into Hazleton No. 5; and a 1½-in. bore-hole is now being driven to tap the old Diamond mine, which has been filled with water for more than 20 years. Other holes will follow. This plant can be utilized in draining all the collieries in that locality, as the mines are all connected underground.

BOSTON ELEVATED RAILWAY plans have been approved by the Railroad Commission of Massachusetts. The approval specifies that the cars may be somewhat smaller than those in use on ordinary steam railways; that they be run on two rails parallel to each other, and on a level; that the gage is to be 4 ft. 8½ ins.; that the roadway rest upon an iron or steel structure, elevated to a proper height above the street surface, and that the motive power be electricity. But the authority to issue $15,000,000 of stock at one time was not granted. The Commission fixes the original stock at $10,000,000, to be issued from "time to time," only for purposes designated in the order; and it authorizes an issue of $500,000 at once, for the purpose of depositing $300,000 with the State Treasurer and for paying engineering and other preliminary expenses. The original bill permitted an authorized stock of not less than $10,000,000, with power to increase the same, from "time to time," to a sum not exceeding $20,000,000 in all. The Board, in refusing the amount asked for, does not deem it necessary to now provide for expenses dependent upon future legislation, agreements, leases and other conditions not now existing.

THE BALDWIN LOCOMOTIVE WORKS received on July 27 an order for 20 locomotives for Japan, making, with 30 already shipped, a total of 50 for that country. Americans have no difficulty in meeting English, German and French competition in locomotive building for the Eastern market; the only difficulty lies in the exceedingly close competition among American manufacturers.

AMERICAN RAILWAY CARS, built by the Jackson & Sharp Company, of Wilmington, Del., have been ordered by the Southeastern Railway Company, of England. A sample car shipped to England met the approval of the Board of Directors, and a contract followed for a considerable number. These cars are to be 55 ft. long and of standard width, with end entrances, and the interior arrangement of an American parlor car, with all the decoration familiar to American travelers. The cars will be lighted with electricity from accumulators beneath the car. The trucks will be furnished by the railway company, and English buffers will be used.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred July 28, on the Central Pacific Ry., about six miles west of Reno, Nev. It is supposed to be the result of rails spreading. Six out of fifteen Indians on the baggage-car were killed, while the others were more or less seriously injured. The engineer, fireman and express clerks were also injured.

ANOTHER SERIOUS ACCIDENT on the Cleveland, Cincinnati, Chicago & St. Louis Ry., July 30, at Thorntown, Ind., was caused by a coupling pin being deliberately driven into a switch to hold it open. The engineer, fireman and two tramps are reported killed.——Two Lehigh Valley freight trains collided July 30 at Depew Junction, N. Y. The engineer and one fireman were killed. A disregard of signals is given as the cause of the accident.——As the result of a washout on the Kansas Pacific Ry., 40 miles east of Denver, on Aug. 3, an express train was wrecked, killing two trainmen and injuring several passengers.——Another washout accident happened July 29 on the Long Island Ry., between East Northport and King's Park. The engineer saw the danger, but slippery tracks prevented the train stopping in time. Three were injured seriously and three others badly.——A Missouri Pacific passenger train ran into four freight cars standing on the main track at Yates Center. The engineer and fireman will probably die.

A CYCLONE IN ILLINOIS, on July 30, caused loss of life and considerable damage to property near San Jose, Ill. Five persons were killed and three injured in the destruction of one farm house, and it is expected that other casualties will be reported later.

LEHIGH UNIVERSITY will not "close its doors," owing to lack of financial support, as was currently stated in the daily press and noted by us from that source. Direct information from the faculty of that institution authorizes an emphatic denial of the rumor. The university will be opened as usual in September and the appropriation of $150,000 by the State of Pennsylvania will entirely relieve the temporary and partial failure of income. This will be pleasing information to the many graduates of Lehigh, and especially to the engineers who started in their professional life from that excellent school.

THE FAST MAIL TRAIN between Chicago and Kansas City, which has recently been put on by the Atchison, Topeka & Santa Fe Ry., makes the run of 458 miles in 11½ hours, or at the rate of 40 miles per hour, including nine regular stops, two changes of locomotives, and stops at water stations. The train leaves Chicago at 2.45 a. m. (instead of 1.35, as formerly), thus enabling the Chicago morning papers to be put on board, and it is due at Kansas City, Mo., at 2.15 p. m. The reduction in time, as compared with the former schedule, is four hours. The time of the eastbound Overland Limited has been reduced to 14 hours between Kansas City and Chicago.

A FLOOR COLLAPSED in a dancing pavilion at Columbia Park, Chicago, July 25, but fortunately nobody was hurt. In consequence of a heavy rainstorm a crowd gathered in the pavilion, and the weight caused the floor to give way gradually at the center, but, as it was not far above the ground, very few people were thrown down.

THE INSTITUTION OF CIVIL ENGINEERS, on March 31, 1897, had 6,204 members, divided as follows

Honorary members	21
Members	1,936
Associate members	3,916
Associates	331
Total	6,204

On the corresponding date of 1896 the roll numbered 6,030, the net gain being 174 in the year. Including 886 Students, the roll, on March 31, 1897, footed up to 7,090. During the session the Council considered 390 applications for election and 99 transfers; the actual elections in the year included 2 Honorary Members, 37 Members, 279 Associate Members and 8 Associates.

THE VALUE OF THE WATER-WORKS at Los Angeles, Cal., has been reported on at length by Mr. J. H. Dockweiler, City Engineer. The plant is owned by the Los Angeles Water Co., but the city proposes to own and operate works, either by the purchase and improvement of the present works, or the construction of a new plant. The report shows that 55% of the 320 miles of pipe in the distribution system consists of 2-in. pipe, and 24% of 3 and 4-in., making 79% 4 ins. or less in diameter. The pipe was uncovered in 318 places. Cast-iron pipe laid in 1869 was found in "a perfect state of preservation," but with their asphalt coating entirely gone. On all kinds of pipe the asphalt coating was found to be in poor condition. In sandy or loam soil the bare metal of cast-iron pipe has stood without rusting, but in the hard adobe soil slight rust was found, although the pipe was practically uninjured. Wrought-iron pipe, mostly 2 and 3 ins. in diameter, did not make so good a showing. Sheet iron and sheet steel pipe, and cement-lined sheet-iron pipe were found to be in various states of preservation, but in general it is believed that with the exception of a small amount of 44 and 48-in. pipe, all of the various kinds of sheet metal pipes, comprising about 60% of the whole system, will have to be replaced within ten years. The estimated value of the physical part of the work is $1,190,000, and the estimated cost of needed improvements and extensions, in case the city should buy the works, is $2,300,000. It is stated that the company has offered to sell its works to the city for $3,000,000.

A NUMBER OF DAM FAILURES have been reported in the last two weeks. On July 27 it is reported that a dam forming the 100,000,000-gallon impounding reservoir of the Butler (Pa.) Water Co. failed, doing comparatively little damage. The dam is said to be 350 ft. long and 25 ft. high, and the break is reported as about 50 ft. long. On July 30 a small dam failed near Middletown, Conn. It appears to have been of masonry and to have furnished power for several small manufactories. Early in July a dam across the Rum River, at Anoka, Minn., was damaged by high water. Mr. Geo. D. Bartlett, Mayor of Anoka, informs us that the dam was owned by the Pillsbury-Washburn Flour Mills Co., and that the break started by water undermining the west end of the dam. A cofferdam for the repair of the structure was built and when completed high water came, carrying away the cofferdam and half of the original structure. A new dam is being built, the flour mill meanwhile being operated by the supplementary steam plant.

THE WRECK OF THE LAKE STEAMER "Cambria," of the Windsor, Detroit & Sault Ste. Marie line, occurred on Lake Huron, near Sarnia, July 28. The vessel ran into a drift of logs which had become detached from a raft, and her wheels were smashed, machinery disabled and hull stove in. The ship was loaded, and the passengers were landed in safety, but the ship soon began to break up in the heavy sea that was running. It was an old side-wheel steamer of 400 tons.

A BRIGHT-WORK PAINT, for machinery in transport, is said to have lately been adopted in Germany for which many good qualities are claimed. Its exact composition is not stated, but grease and volatile oils are said to enter into it. Applied to iron it provides an air-tight skin, which adheres tightly to the metal and is proof against salt water, salt air, rain, snow, steam, gases and the fumes of acid or ammonia. It is absolutely neutral and leaves no mark when removed. It is transparent and does not crack nor rub off in handling.

THE BLACKPOOL EIFFEL TOWER, in England, was practically destroyed by fire on July 23. This copy in miniature of the Paris tower was 350 ft. high and was built about four years ago.

THE PITH OF THE SUNFLOWER STEM is said to be the lightest substance known. Its specific gravity is 0.028, as compared with 0.09 for elder-pith, hitherto recognized as the lighter material, and 0.1 for reindeer hair and 0.24 for cork. The sunflower is extensively cultivated in Central Russia, mainly for its seeds. But the discovery of the extreme lightness of its pith has added to its commercial value. For life-saving appliances at sea, cork has a buoyancy of 1 to 5, and reindeer hair 1 to 10, while sunflower pith has a buoyancy of 1 to 35.

THE NEW DISMAL SWAMP CANAL, 26 miles long, 12 ft. deep and 60 ft. wide, may be completed within the next ten months, says the Portsmouth, Va., "Star." The 4-mile feeder from Lake Drummond has been deepened to 9 ft. and widened to 40 ft., and about 10 miles of the main canal are completed. The estimated cost of the improvement, to Messrs. Sanford and Brooks, is placed at about $1,000,000. Of the two locks, one at either end, the southern lock is being built, and the one at Deep Creek, at the north end, will be commenced in October.

THE HANDLING OF MATERIAL AT THE BLAST FURNACE.*

By Axel Sahlin, M. Am. Inst. M. E.

The evolution of the blast-furnace, especially the American blast-furnace, during the last third of a century has indeed been radical, making the question of getting the material to the furnace and the product away from it promptly, cheaply and regularly—the problem once satisfactorily solved by the cart or sled, the wheelbarrow and manual labor—one of great difficulty and grave importance.

It is my purpose in this paper briefly to record some of the most important steps which have been taken to solve this problem, and to offer a few suggestions as to what might next be done to keep up with, and anticipate, the increasing producing capacity of the blast-furnace.

The spread of the railroad net-work in all iron-producing districts early introduced the freight-car and the car-load as the natural unit in the transportation and handling of stocks; and, except where the furnaces are located directly on navigable water-fronts the yards and stock-houses are arranged with a view of handling such cars to the best advantage. The elevated track or trestle is therefore a universal feature of the stock-yards. It was a natural step to build, between these trestles and under the tracks, bunkers or hoppers, with funnel-shaped bottoms, from which the stock could be drawn without shovelling. These hoppers are great labor-savers, if rightly proportioned and provided with efficient drawing-doors, but for years past, the success experienced with them has generally been indifferent; the reason being, that the shape of the hoppers often was governed, not by the laws of gravity and friction, as it should be, but rather by the proportions of the existing trestles, without much regard for the mechanical necessities of head-room, pitch, etc.

An interesting installation of hopper-storage is in use at the furnace plant of the Dowlais Iron Company, at Cardiff, South Wales. The plant consists of four furnaces with a stated capacity in 1895 of 200 to 225 tons per day, each. Behind the furnaces, and on lines parallel with them, are located two rows of upright cylindrical sheet-metal tanks, about 30 ft. in diameter and 60 ft. high, resting on columns. The lower part of these hoppers is contracted and provided with chutes for drawing the stock, as required, direct into the charging-bogies. The flow of stock through each chute is regulated by a sliding door, entering the chute from the under side through a slot extending from side to side across the bottom of the chute. This device works perfectly, and is worthy of attention. Over the top of each row of tanks runs a standard-gage track. At each end of these tracks is built a powerful hoist, operated by water-filled counterweights. At one end, the loaded wagons are raised to the level of the overhead-track, where a special engine hauls them over the proper tank. The wagon is discharged by dropping the bottom. It is then moved to the opposite end of the overhead track, whence it is lowered to the yard-level by a hoist similar to that at the raising-end. It must be borne in mind, that the four-wheeled English goods-wagon has a capacity of not above 10 tons, and is therefore better adapted than the American 60,000-lb. freight-car to this method of handling. The same height and construction of tank is used for handling coke, as well as flux and ore. It was reported, that, after the coke-tanks were once filled, the abrasion and crushing of the coke was very insignificant. By means of this apparatus, five men on the turn were able to stock each furnace. The men were paid by the ton of product, and were said to earn from eight to nine shillings per day. It is evident that the storage-capacity under this system is limited, and it would hardly be available where a winter supply of ore must be laid in, or a large reserve of stock for other reasons must be kept at the furnace.

In plants requiring a large storage-capacity, the trestles are often extended to a considerable distance from the furnace. The expense of hauling an increasing number of charging bogies grows in proportion to this distance, and would be prohibitory without improved transfer-arrangements.

The Maryland Steel Company, of Sparrow's Point, Md., has overcome the difficulty of a long transfer by employing electric trolley-cars. Behind and parallel to the four furnace-stacks is located the stock-house, a magnificent steel structure 1,180 ft. long and 100 ft. wide, containing four lines of tracks, supported on trestles, 20 ft. high. The trestles are continued some 600 ft. beyond the end of the stock-house; the extension being used exclusively for the storage of foreign ore. The hoists are of the ordinary upright reciprocating type, with platforms 12 ft. 6 ins. by 12 ft. 6 ins., served by Crane hoisting engines with 14 × 16-in. cylinders. Along the front of the stock-house is located a narrow-gage, depressed trolley-track, extending beyond the extreme end of the trestles. Over the track is suspended the trolley-wire, carrying a 250-volt current. On this track travel a number of motor-cars, each driven by a 6 HP. motor and carrying two transverse tracks, level with the floor under the trestle, and sufficiently long to receive the wheels of the charging-cars, which, by a simple locking arrangement handled by the operators, are scotched in proper position. The motion of the transfer cars is perfectly controlled from a cab or stand at the rear end of the car. The operator becomes in a short time so expert that he is able to stop his car within one-half inch of the point desired. Under each trestle or bin, are two parallel tracks at right angles to the stock-tracks, corresponding with those on the transfer-cars. In front of the hoist are placed the scales, of the Fairbanks six-beam type, but with the levers and edges placed overhead, and the scale-platforms suspended underneath—an arrangement, which facilitates inspection and repairs, and brings the delicate working parts of the scales away from the dust. Each scale and hoist platform carries two tracks corresponding to those on the transfer-cars. Between the scales and the hoist-cages is placed a depressed transfer-table operated by blast-pressure, supporting six transverse tracks, so spaced that, at either end of the stroke, four of them correspond to those on the scales and hoist-platform, while the remaining two match return-tracks for empty cars.

One weigher, with two assistants and two motor boys on each (twelve hours') turn have, with this apparatus, without difficulty, handled stock for a furnace producing nearly 10,000 tons of iron in one month, and with a record of 392 tons in 24 hours. At times the ore is brought on to the scales from a distance of 900 ft. Two transfer cars are used for each furnace. They are provided with drop-bottoms, held by a simple and very effective toggle-lock. The coke-car has a capacity of 55 cu. ft. or 1,680 lbs. The ore and limestone car has a capacity of 30 cu. ft., or about 2,240 lbs. The cycle of operation, including the hoisting, discharge and return to motor-cars of four charging cars, requires about 2 to 2½ minutes. For handling the heavy charging-cars, the top platform is fitted with tracks running across the hopper on either side of the bell-rod. The two cars raised on the same hoist are run, one behind the other, upon one of these tracks; the bottoms are dropped by springing the toggle-locks; a special air-cylinder lifts the far end of the track, and the cars are sent by gravity back to the hoist-cage. Such was the arrangement used on the first furnace equipped for this charging method. When the furnace was blown out it was found, however, that the continuous dropping of the stock at four points only had caused the furnace walls to cut so that the cross-section of the upper part of the shaft was nearer square than cir-

Fig. 20.

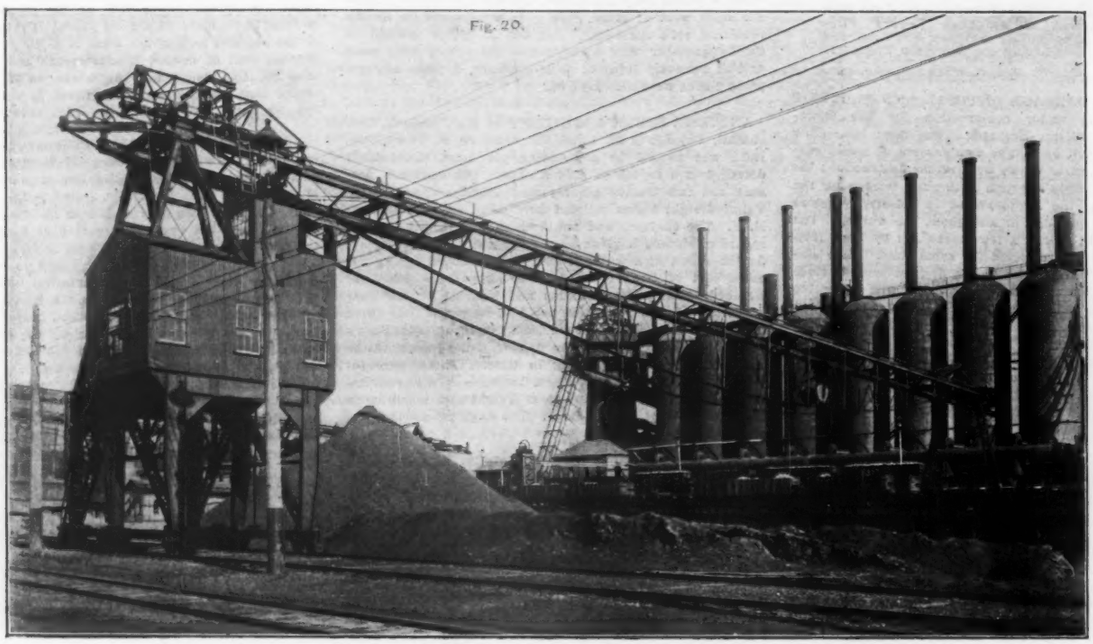

FIG. 1.—ORE HOISTING AND CONVEYING MACHINERY AT THE DUQUESNE FURNACES OF THE CARNEGIE STEEL CO.
Built by The Brown Hoisting and Conveying Machine Co., Cleveland, O.

cular. The system had, however, given such good satisfaction and economical results, that it was decided to overcome this difficulty by placing the tracks spanning the hopper on a turn-table, revolving through an angle of 45° and worked by air pressure. The cars constituting every alternate charge are revolved by means of the table, so that stock is dropped in eight places instead of four, insuring better distribution and decided economy in fuel. To make sure that the table is regularly revolved, a recording instrument, inaccessible to the top-fillers, is attached to the operating cylinder. Three men on each turn do the work on the top of the furnace.

Since the days of the inclined foot-bridge and the wheelbarrow, the improvements in the stock-hoist have kept pace with the efficiency of the furnace proper. As a first step, rails and a platform-car, carrying the wheelbarrows, or, later, the charging-bogies, were placed on the inclined bridge, water, run into a counter-weight tank, furnishing power. One such bridge often served two or three furnaces. Later, hydraulic or pneumatic pressure took the place of water acting by weight. The inclined bridge gave way to the vertical hoist-tower of the present day.

In 1860 Mr. John Fritz designed and built for the Bethlehem Iron Co. a number of pneumatic hoists, which are yet in operation, and which, so far as I know, have not been described in the "Transactions of the Institute." These hoists were a striking improvement on anything then in use, and the principle employed in them may yet be utilized, in connection with an air-compressor and higher pressure, in designing a modern rapid-moving hoist of large capacity.

The single cage is placed between two cast-iron air cylinders, extending the entire height of the hoist-tower. It

*Abstract of a paper read at the Chicago meeting of the American Institute of Mining Engineers.

is guided by rollers traveling on V-shaped rails, cast in one with the cylinders. In the bore of these work leather-packed pistons, to each of which are attached two hoist-ropes. These ropes run through the upper head of the cylinders over sheaves, supported by the top-frame of the tower, the opposite ends being secured to the hoist-cage. When cold-blast pressure is admitted to the cylinders above the pistons, the load is raised; when the air is exhausted the platform is lowered. A hoist, built on the same principle, but with one central air-cylinder, was installed at the Freemansburg furnace of the Bethlehem Iron Co.

Such a hoist, slightly modified, was also built in 1871 by the late Mr. George Fritz for Furnace No. 5 of the Cambria Iron Co., Johnstown, Pa. As late as in 1885 this hoist was working, side by side, with a double-cage steam-hoist at Furnace No. 6, the latter being equipped with an engine of good make (as hoisting engines were built in 1878). The air-hoist gave far less trouble and caused fewer delays than the steam-hoist. It had, however, no spare capacity, and both hoists were soon afterwards altered and equipped with modern engines.

The successful blast-furnace hoisting-engine is of comparatively recent date. In 1872 the Crane Elevator Co., the Weimer Machine Co. It consists of a single inclined track, 7 ft. 7 ins. gage, 301 ft. long, with a rise from the stock-house floor to the tunnel-head of 95 ft. The track crosses the hopper above the depressed bell-beam, from which the conical bell is suspended by a short link only. On the track travels a drop-bottom tank 7 ft. 2 ins. in diameter, 7 ft. 1 in. deep, with a capacity of 8,000 lbs. of stock. Recently the original drop-bottom doors have been replaced with a bell, whereby the capacity of the tank is somewhat increased and a better distribution secured. The 6-foot diameter hoisting-drum is carried on cast-iron brackets, bolted to the top of the furnace-shell. It is geared 6 to 1 to a duplex, vertical hoisting engine (16-in. cylinders, 20-in. stroke), which is bolted to the furnace-shell below the hoisting-drum. The skip makes a trip in two minutes. The hoist is satisfactory, and has been duplicated at the furnace of the Duluth Iron and Steel Co., Duluth, Minn.

The Thomas patent furnace-filling apparatus, which is in successful operation at the Pioneer furnaces at Thomas, Ala., permits the hoisting of narrow-gage drop-bottom cars to the top of the furnace and discharging them automatically.* Each filling-car has a capacity of

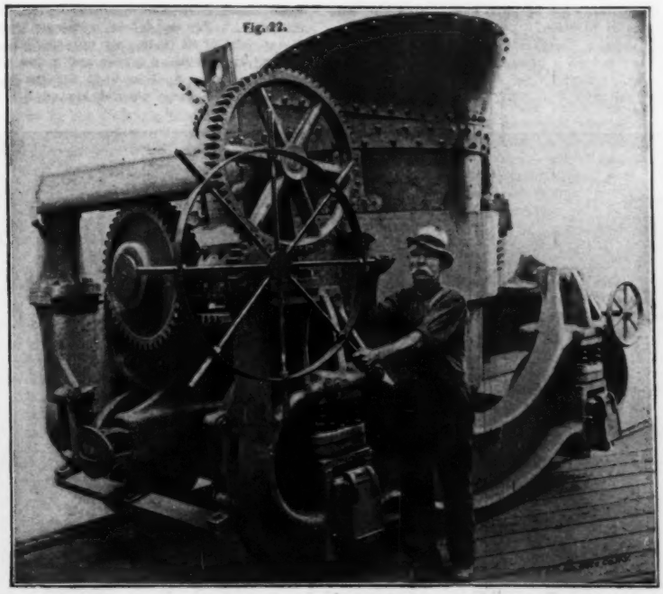

Fig. 22.

FIG. 2.—TRANSFER CAR AND LADLE FOR MOLTEN IRON; 18 TONS CAPACITY. THE MARYLAND STEEL CO.

or, rather, their predecessors, put their first engines in operation at the Joliet Steel Works, the Vulcan Steel Works, of East St. Louis, the Spearman Iron Company's furnace and some other plants. These engines were belted. Since that day the hoisting-engine has been strengthened throughout, perfected and enlarged to meet the growing requirements. Steam-engines had, it is true, been used for blast-furnace hoists earlier, but they were crude, deficient in reliable stop and safety-appliances and did not gain or deserve general confidence.

Great credit is due to the engineers who have evolved the present compact, faithful, ever-ready hoisting-engine, without which furnace-managers would hardly succeed in making the wonderful records, with which they are now astonishing the technical world.

But we have gradually entered on a new departure. The vertical hoist, if not the hoisting-engine, has reached its limit. It is difficult to see how, without extravagant use of labor, more than from 1,500 to 1,600 tons of material per 24 hours can be brought in hand-bogies to the hoist-platforms, lifted 100 ft. or more, removed from the platforms, dumped into an open hopper and the empty bogies returned to the stock-house. These operations, incessantly repeated with the utmost promptness, become a task almost beyond the endurance of man, and so we are returning again, in blast-furnace construction, to the inclined plane—now, however, made to carry larger cars or skips, and designed to raise a considerable portion of a charge on each trip. The real or assumed difficulty of obtaining proper distribution in the hopper has for years been made an objection to this method of elevating the stock. It was, however, in use at the Lucy furnaces in Pittsburg as early as 1881, and at the Lebanon furnaces, Lebanon, Pa., since 1885. In most of the recently built furnace-plants the skip-hoist is made a feature, and the labor of the top-fillers has been dispensed with. By means of a double hopper, into the upper part of which the skips are emptied, the stock is undoubtedly distributed with sufficient regularity.

The skip-hoist at the Lebanon furnaces was designed by about 2,000 lbs. of coke, or 4,500 lbs. of ore. The stock-house, 70 ft. wide and 650 ft. long, is located 150 ft. from the furnace. The stock is unloaded from trestles in the usual manner. The filling-cars travel on 30-in. gage tracks, extending the entire length of the stock-house and having turnouts and side-tracks running into the different stalls. At the center of the stock-house is a turntable for swinging the cars on to the scale track, whence they continue to the foot of the inclined hoist-plane. This is 190 ft. long and has a pitch of 25°. It is composed of two spans of 7-ft. deep lattice girders, spaced 7 ft. c. to c., and designed to carry a live load of 20,000 lbs. The girders are supported at the foot by a masonry pier, in the center by a steel structure, and at the top by heavy brackets riveted to the furnace-shell. To the top flange of the hoist-girders are bolted cross-ties, which support a single four-rail track and a stairway. The gage of the two outside rails is 30 ins., and on these run the filling-cars. The inside rails are 22 ins. gage. They support a special truck, permanently attached to the two ¾-in. hoisting-cables, and designed to push the loaded filling-cars ahead of it to the top of the incline. The outside rails connect with the tracks to the stock-house and scales, while the inside rails continue to descend below the general stock-house level, forming between them a pit or well, into which the pushing-car sinks, permitting the empty filling-car to continue over its top on the track, back to the stock-house. The loaded filling-car, is, in its order, brought from the scales across the pit containing the pushing-car, which is made to re-ascend behind it, carrying it to the tunnel-head.

The furnaces are of moderate dimensions, being 75 ft. high, with a bosh-diameter of 16 ft. 6 ins. The largest amount of stock required to be raised in one week has been 5,500 tons. This has been handled by the hoist without crowding, and with considerable capacity to spare. This apparatus is undoubtedly economical in first outlay, clever in design and efficient in performance.

*This hoist was described and illustrated in Eng. News Feb. 28, 1891.—Ed.

Recently double track, alternating inclines with self-dumping skips and intermediate hoppers have been designed and built which will have a large capacity, but which I am not at liberty to discuss at the present time. It is to be hoped that a description of the filling-arrangement at the new Duquesne furnaces will soon be placed before the Institute, as the recent performance of this arrangement widely surpasses anything attempted at any other blast-furnace.

At furnace-plants located on navigable water-fronts we find the Brown hoisting and conveying-apparatus universally adopted for unloading vessels and conveying the ore to the place of storage. Its mode of operation is too well known and understood to require special description. The great advantage of this device, as compared with ordinary derricks, cars and trestles, in the rapidity of transfer, capacity of storage on a given area, low first cost of plant per ton of material stored, and in avoiding all rehandling, is obvious.

With one of these machines at the works of the Illinois Steel Co., South Chicago, between 500 and 600 tons of hematite ore have been unloaded from steamer and stored at a point 280 ft. from the ship, in 10 hours by 8 men. It is on record that on Sept. 7, 1894, the large steamer "S. S. Curry," with 4,569 gross tons of ore was unloaded at the above works in 11 hours, working nine hatches, that is with nine machines, with 63 men in the vessel and 12 men operating the machinery. The Brown machine may be built as a gantry crane, spanning the stockyard as well as in the ordinary cantilever form traveling or revolving. It is driven either by electricity or by steam.

The rope tramway is frequently used around blast-furnace plants, especially on the continent of Europe, for long transfer of stock and for removing cinder. As it may be built in spans of 300 to 400 ft. or more, it is especially valuable in crossing inaccessible areas. As instances, I refer to the installations long in use at Gutehoffnungshutte, Oberhausen, Germany, for transporting the cinder from the blast-furnaces to the dumps across the main line of the Berlin-Cologne Railroad, and to the cable carrying coal from the River Meuse to the extensive works of the Societe John Cockerill, Seraing, Belgium.

One of the best applications of this system to blast-furnace plants in the United States may be seen at the works of the Buffalo Furnace Co., Buffalo, N. Y., where vessels bringing Lake Superior ores are unloaded at the rate of 2,500 to 3,000 tons a day, and the ore is distributed by wire tramways to different points in the stock-house some 2,000 ft. away. In connection with quarries and mines, the system is successfully operated at many places in this country, as well as in Europe.*

The manner of handling ore at the Duquesne furnaces of the Carnegie Steel Co., Ltd., is shown by the illustration, Fig. 1. The gantry cranes, or bridge-tramway machines, are operated by electricity. They have a clear span of 233 ft., covering the stock-yard, and a cantilever extension of 33 ft. for additional, covering the trestle-tracks. The bridges will clear a stock-pile 58 ft. high. These cranes remove the ore from the cars, depositing it in the stock-yard, using for this purpose self-tipping ore-tubs; or, they carry the ore from the stock-pile to the charging-hoppers. For this work automatic shovels, designed and patented by the Brown Hoisting & Conveying Machine Co., take the place of the self-dumping ore tubs shown in these illustrations. The working capacity of each crane is from 1,500 to 2,000 tons of lake-ore per day of 10 hours.

The facility with which power may be distributed to any part of the stock-yard or plant by means of electricity, opens a new field for ingenuity in devising labor-saving appliances. All breaking and screening of material by manual labor should be a thing of the past. Electrically-driven conveying belts, a good form of which is described by Mr. Thomas Robbins, Jr., in the "Transactions" for 1896, Vol. XXVI., p. 78,† should take the place of the wheeling of materials from inaccessible portions of the yard. Electrically-driven slow-moving bucket elevators may be placed anywhere around the plant without the old-time consideration for distance from steam-supply, and will handle and dispose of coal, coke dust, ashes, flue-dust, sand or clay economically and promptly. The electric traveling crane, which should cover every modern cast-house, will handle, at a nominal cost, heavy castings, such as bells, hopper-rings, hearth and bosh plates, iron and cinder troughs, chills and other spare parts requiring periodical renewals. It will raise the worn cinder cars from their trucks and replace them in a small fraction of the time generally consumed for this operation. It will, if desired, remove the entire product in the form of pig-beds from the casting floor, and may give invaluable assistance in cleaning up a wreck, break-out or boil of iron, and thus save the exasperating delay and disorganization of labor, with which all who have been practically engaged around a furnace plant are so unpleasantly familiar.

Comparing the methods for bringing the stock to the furnace tried at different plants, and the results obtained by them, it seems that a combination of some suitable form of the Brown hoisting and conveying machine, with traveling steam shovels for reloading the ore, hopper-

*See "Trans. Am. Inst. M. E.," XIX., 760, and XX., 766, for description of its construction and use.

† Eng. News, March 26, 1896.

storage for coke, and flux, electric transfer and a good form of the inclined skip-hoist, raising a large portion of the charge on each trip, would represent the most effective arrangement which the present state of the art will permit.

It is worthy of note, that while the stock-yard, storage, transfer arrangements and hoist, have been improved step by step, the cast-house, generally speaking, remains to-day in exactly the same condition as that of the old-time charcoal furnace. As we have forced the furnace to an increased output, our only resource seems to have been to build additions to the cast-house and make more frequent casts. But we still continue to break up the pig-beds with the crowbar and hand sledge; we carry the iron, piece by piece, from the casting-floor to the car by manual labor, we form the mold for receiving the iron anew for every cast, with a large expenditure of labor and loss of time, which we can hardly afford—all in the same manner as a generation ago. But it does not follow that this part of the furnace-plant has been neglected, but rather, that the difficulties encountered in devising practical improvements have been, at least until very recently, too great to be overcome.

Among the few improvements in the method of casting, the use of iron chills is the oldest. The chills save labor, especially while new, and facilitate the breaking of the pig beds; but they are high in first cost, reduce the capacity of the casting-floor and close the grain of the iron. They will, therefore, never be used for foundry-iron until our foundrymen consent to buy their metal on analysis instead of on fracture, as at present. The life of the chill is only from one to three years, depending partly upon the quality of the metal, partly on the amount of patching and building up that the furnace manager is willing to have done before condemning a defective chill. It is, therefore, an open question, whether money is lost or made by casting in chills. In most cases a slight saving can probably be shown. For basic iron, chills are valuable, as they leave the pigs free from a siliceous coating of sand. When Sunday-iron only is handled in the cast-house, the saving by the use of chills is also more marked.

The direct-metal process, or the running of the liquid iron into ladles to be carried to a receiver, or direct to the Bessemer converter, is a radical improvement in the method of disposing of the metal, but its scope is limited, as it can be used only in conjunction with a steel-plant; and even then the metal produced while the steel works are idle, briefly named the Sunday-iron, must be taken care of at the furnace, for which purpose labor and casting-floor must be kept in readiness. It is often an awkward problem for the manager profitably to employ this reserve force, which may be called on at any moment.

Fig. 2 shows an improved form of an 18-ton transfer car and ladle, as used by the Maryland Steel Co., and recently adopted by the Cambria Iron Co., the Cleveland Rolling Mill Co., and the Pennsylvania Steel Co.

The Dowlais Iron Co. has introduced a device, invented by Messrs. Edward Evans and Enoch James, by means of which the handling of the metal is greatly simplified. The well-built furnace plant at Cardiff consists, as above stated, of four furnace stacks making Bessemer iron for the extensive acid open-hearth plant connected with the works. It may be considered as the exponent of the modern English furnace plant. In front of the furnaces is located the uncovered casting-floor, intersected by curving, depressed cinder tracks, which leave the casting-beds for each furnace in an irregular shape, unusual to the American eye. An elevated traveling crane runs from one end of the plant to the other, on tracks parallel with the furnaces, and entirely covering the casting-floors. The pig-molds and runners are formed in sand to wooden patterns. When the metal, cast into pig-beds has cooled sufficiently to stand handling, the beds are successively lifted out of the sand by means of the traveling crane and carried to the end of the track, where they are stacked or delivered directly to the pig-breaker, a hydraulic machine by which the bed of pigs is broken up. The pieces of iron slide down an incline apron to the wagon placed below the breaker. At the time of my visit only two furnaces were in operation, producing together about 400 to 450 tons of iron per day. It was reported that four men on each turn did all the work on the two casting-floors. Two men and two boys, on day-turn only, handled, broke and loaded the entire product. The handling of pigs in units of beds, weighing from 2½ to 3 tons, instead of pigs weighing from 70 to 120 lbs., is undoubtedly a step in the right direction.

As improvements in the method of dealing with the iron, two auxiliary machines for opening and closing the tap-hole deserve special mention.

The tap-hole drill, a pneumatic rock-drill, guided by a strong frame and fed by a pneumatic cylinder, has been described by the inventor, Mr. David Baker, in the "Transactions" for 1892, Vol. XXI., p. 588. The tap-hole closing-machine invented by Mr. Samuel Vaughen, is used by the Maryland Steel Co. It consists of a pneumatic cylinder controlled by a plain side-valve. In front of the air-cylinder is bolted a second cylinder, which is filled with balled stuff or clay, such as is used for closing the tap-hole. The clay is forced out of the nozzle of the forward cylinder and forced into the tap-hole by advancing a plunger fastened to the protruding end of the air-cylinder piston-rod.

Both the drill and the closing machine, which is popularly known as the "gun," are swung from light cranes fastened to the furnace columns, and are held in position, while at work, by suitably, easily detachable clamps and hooks. Together they have proved themselves time-savers and a very valuable aid in controlling the flow of the metal from the furnace. With their aid, a cast can be made without the blast being taken off the furnace.

The problem of designing a practical machine for the continuous or interrupted casting of blast-furnace metal has received considerable attention. Several patents for various contrivances, indicating the widely-felt need of such a machine, have been granted, but until a short time ago none of them had received a practical demonstration. The advantages to be gained from an economical and metallurgical point of view, by the production of clean, uniformly-sized, sand-free, pig-iron have been ably and forcibly presented by a member of the Institute, Mr. Henry D. Hibbard, in his paper on this subject, read before the British Iron and Steel Institute, in 1896. Since this paper was published experiments have been in progress, resulting in the evolution of the Uehling machine for casting, conveying and automatically loading blast-furnace metal, which is now in successful operation at the Lucy furnaces, Pittsburg, and, on the strength of its performance there, has been adopted to replace the system of sand-casting and pig-breaking hitherto used at the Duquesne furnaces.*

One double casting machine readily handles one ton of metal per minute. The largest quantity of iron cast in one single day has, at this writing, been 729 tons, which represents the daily output of the two Lucy furnaces.

The importance of this new development and its effect on the arrangement of the future blast-furnace should not be overlooked or underrated. It would seem as if the metal should be run from the blast-furnace into a mixer or receiver heated with furnace-gas and of sufficient capacity to hold at least two casts. From this mixer it should be cast directly into the molds of the casting machine. With a sufficient receiver-capacity, we may safely dispense with the expensive cast-house and with the host of men employed therein, and at the same time we should obtain a more uniform metal, and may tap the furnace at any time we choose. From a metallurgical point of view, the advantages thus secured are equally worthy of consideration.

Sand-free pig-iron is imperatively demanded by the basic open-hearth process. The sand adhering to the iron in the form of free silica is far more destructive to the basic lining than is the silicon chemically combined in the metal. For sand-free metal the limit specified for the amount of Si in the pig may therefore be raised, admitting for use many grades and makes of iron, which, if cast in sand, would be unfit for the basic open-hearth process. The same observation applies to iron used in the puddling process. In the Bessemer works and foundry, in short wherever the iron is melted in a cupola, absence of sand, while not affecting the composition or metallurgical value of the metal, effects a marked saving in flux, in fuel, in iron-loss in the slag, and in the labor of bringing the considerable quantity of sand to the cupola and the slag away from it. One ton of pig-iron cast in sand weighs, commercially speaking, 2,268 lbs., while 2,240 lbs. is the accepted weight of one ton of sand-free iron. It is now customary to pay a premium of about 25 cts. per ton for iron cast in chills, over and above the price for the same iron cast in sand. Yet, the iron cast in chills is far from sand-free, as the chills are seldom perfect, being more or less patched with sand; and, besides, some sand is carried from the sand-runners and adheres to the iron. If metal cast in chills is at a premium, metal cast in the casting machine, and therefore absolutely sand-free, should command a yet higher premium.

Many of our foundrymen, who are compelled to work without the aid of a laboratory, and who have been trained to judge their iron and to make up their mixtures from the appearance of the open fracture, will undoubtedly object to the casting in chills, which deprives them of their accustomed guide for conducting their operations. But if the foundryman would follow the example of the blast furnace manager, who invariably judges his metal from the appearance of the fracture of a sample cast in an iron chill, he would find such a fracture more reliable and less variable than that of the slowly-cooled sand-pig. Besides, it is to be hoped that the progress of the iron-cast-

FIG. 3.—THE HOWDEN SLAG-CONVEYOR AT FURNACES 1 AND 2 OF THE CAMBRIA IRON CO., JOHNSTOWN, PA.

*The Uehling casting machine and conveyor were described and illustrated in Engineering News of April 29.—Ed.

ing industry will be such, that before long the assistance of the chemist and the laboratory will be as helpful and indispensable in the foundry as it is to-day in the steel plant, or at the blast furnace.

In dealing with the blast-furnace cinder, our methods to-day are nearly perfect. As late as 1883 it was still customary at most blast furnaces to form rough molds in slag, on what used to be called the cinder-wharf. Into these the hot cinder was run. It was broken before cooling and loaded on dump-cars by manual labor, or it was formed into round cakes, often with an iron staple cast into the center of each cake, for convenience of handling. The cakes were lifted by a swinging crane and loaded on cars. Men were required to prepare the molds and runners, to load the cinder, and afterwards on the dump to unload the unwieldy masses. Cinder-cars with removable tops next came into use. The repairs to these cars were heavy, and considerable labor was required to remove and replace the tops, and to bar the cakes of cinder from the flat bottoms of the cars over the dump. Of late years the Weimer gondola cinder-car has been adopted by most progressive furnace men. It is lined either with fire-brick or with cast-iron staves. The latter are said to be more durable. The repairs to these cars are very light and they are so easily handled and cleaned that the problem of economically handling the blast furnace cinder on the dump may be considered as solved.

The Howden slag-conveyor is a successful machine designed for handling furnace slag destined for road-ballast. It is an English invention, operated in this country under patents controlled by the Cambria Iron Co., of Johnstown, Pa. The conveyors are manufactured by Messrs. Heyl & Patterson, Pittsburg, Pa., to whom I am indebted for data and illustrations. The function of the machine is to cast the slag automatically into shallow pans of cast-iron forming an endless belt, and to cool and granulate the slag so cast by water, delivering it on cars in proper shape for road ballast. The illustration, Fig. 3, shows a recent form of the Howden conveyor, as installed at furnaces Nos. 1 and 2 of the Cambria Company.

The conveyor is 100 ft. long from end to end of track. The pans are built of iron castings in three sections, bolted to one common shaft, fitted with supporting wheels, on which the pans roll over tracks constructed of heavy channels. The shafts act also as pins in the heavy link chain which forms the conveyor. The pans overlap one another, so that no space or joint is left open, where the slag can enter and clog the conveyor.

For the first 25 ft. from the end of the cinder trough the carrying wheels travel over a horizontal track; they are then depressed in passing through a water trough 25 ft. long. The water in this trough is kept at such a level, that it surrounds the pans without covering them, the object being to cool the slag without causing it to boil. The last 50-ft. section of the conveyor track has an upward pitch, sufficient to deliver the slag-cakes directly into the railroad cars. While ascending the slope the pans are freely sprinkled with water, which however does not cause a boil, as the slag in passing through the water-trough has been cooled sufficiently to form a crust over its surface. The empty pans return under the bottom of the water-trough and are thoroughly cooled before they again reach the mouth of the cinder trough.

Granulation of cinder by running it through a flow of water deserves consideration. The granulated slag will find employment as road ballast, for slack brick and for cement manufacture. Mineral wool, or blast-furnace cinder disintegrated by steam, finds a yearly increasing market.

After all is said, the problem of handling material at the blast furnace can receive no general solution. Conditions vary, and we must select in each case the means and methods most suitable; but, given the three vital necessaries, plenty of steam, plenty of wind and plenty of heat, then on the judicious and progressive solution of this problem depends the efficiency and success of the plant.

THE UNIVERSITY OF CALIFORNIA, as established by act of Legislature March 23, 1868, has $4,000,000 already pledged for its support, and asks architects to compete for the plans for new buildings. A committee appointed by the college trustees is ambitious as to plans, and is said to have secured the services of a jury of famous architects, made up of Pascal, of France; Paul Wallot, of Germany; Thiersch, of Austria; Ziegler, of Hungary; Zaconni, of Italy, and Norman Shaw, of England. An American, yet unnamed, is to be added. This jury would meet in Antwerp as soon as plans are all submitted and judge of their merits. The competition is to be international and prizes are to be awarded, and the general prospectus is now being prepared. In addition to the jury named, an Advisory Board has been selected to fix upon such location as will best suit the landscape; and on this board are such men as Alma Tadema, Puvis de Chavannes, Andre, Luciani and Knaus. Mrs. Hearst, the widow of Senator Geo. Hearst, is to meet the preliminary expenses and contribute the money for the principal building. And if the result equals the ambition of the trustees and the fame of the committees chosen, California should have a university to boast of.

THE PROGRESS OF MARINE ENGINEERING IN THE ROYAL NAVY AND MERCANTILE MARINE.*

By Sir Albert J. Durston,† and Mr. J. T. Milton.††

Remembering that the machinery in general use in steamships in 1860 was the simple engine with jet condensers, box boilers, and about 20 lbs. pressure, the practical advances during the period covered by this paper may be summed up as follows: Permanent introduction of the surface condenser (after being tried and dropped) and the general rise of pressure made possible by its adoption. Adoption of the circular or Scotch form of boiler, and consequent further rise of pressure. The successful reintroduction of the compound engine, which had been previously tried and abandoned. The adoption of twin-screws in the Royal navy, and later in the high-speed vessels of the mercantile marine. Steady rise of pressure to limit of economy obtainable in practice with the compound engine. Introduction of the triple-expansion engine, and consequent further rise of pressure to the limit practicable with the circular boiler,and combined with this rise of pressure the adoption in some cases in the mercantile marine of the quadruple-expansion engine. The adoption of water-tube boilers in the Royal navy generally, and in a few cases in the mercantile marine. Extending over the whole period there has been a steady rise of piston speed and speed of revolution, and considerable improvement in design generally, in the distribution of steam, and in the balancing of working parts. There has also been a steady reduction in weight of the machinery and boilers generally, and particularly of the moving parts, due to these causes, and also to the employment of improved materials of construction, and to the more correct determination of stresses, and arrangement of material to meet them.

It is questionable whether any similar period can show a list of solid progress to in any way approach that given above. These advances have only been made possible by many improvements in detail, among which may be mentioned the following: The invention of the Siemens air furnace, and with it the production of mild steel suitable for plates and forgings, in large quantities and in large masses, and of uniformly reliable quality. The production of the corrugated and other similar forms of furnace for boilers. The invention and perfection of the various forms of evaporators and double distillers as a means of supplying fresh water for boilers. The production of high-class steel and iron tubing, chiefly of the seamless type, for boiler tubes and steam pipes. The invention and perfection of various forms of metallic packing, asbestos-packed cocks, and other contrivances for dealing with the higher pressures of steam. A general improvement in machine and other tools, and the introduction of new forms, such as hydraulic forging presses, riveters, and flanging machines, milling machines, gas and electric welding plants; the multiplication of Whitworth gages, and the more general use of these and of taps and die nuts for producing well-fitting screw threads.

The advances in the Royal navy and mercantile marine have run side by side, except perhaps in the three following, which are peculiar to the Royal navy: (1) The increased working pressures and diminished test pressures allowed on boiler shells, and the consequent advantage of a considerable reduction in the weight of the same. (2) The general adoption of the water-tube boiler. (3) The adoption of the closed stokehold system of forced draught, combined with the use of the Admiralty pattern ferrule as a means of obtaining a high power on a given weight for a short time in cases of emergency. In the mercantile marine forced draught is used in many cases, but it is generally the closed ash-pit system which is applied.

Figs. 1 to 4 have been constructed to show graphically the rises in pressure of steam, piston speed, total indicated horse-power, and speed of revolution, which have taken place in the Royal navy between the years 1860 and 1897. In Fig. 1 the total indicated horse-power of all the effective ships has been set up to scale at the years given, and a curve has been drawn through the points so obtained. The indicated horse-power under construction is shown for the later years by setting it up from the first curve, and the second curve so obtained thus represents the total indicated horse-power, including that under construction. In Fig. 2 the rise of pressure is graphically traced. The upper dotted line represents the advanced guard of smaller ships, and the lines have been carried back before 1860 to show where the divergence commenced. It is interesting to notice that the advanced guard has now been outstripped by the main body, the "Terrible" and the "Pelorus" having pressures of 260 lbs. and 300 lbs., respectively, against 250 lbs., the highest in a completed torpedo boat destroyer. The straight line at 1880 to 1897 indicates that the limit of pressure considered desirable with the tank boiler—under the conditions of weight and space allowable in the warships of the Royal navy—had been practically reached. The further rises of pressures after this date have been made by the adoption of the water-tube boiler, and the lines are made thick where the steam is obtained from water-tube boilers.

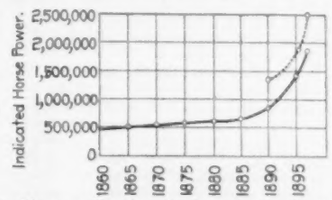

Fig. 1.—Diagram Showing the Increase in the Effective Horse Power of the British Navy from 1860 to 1897, Inclusive.

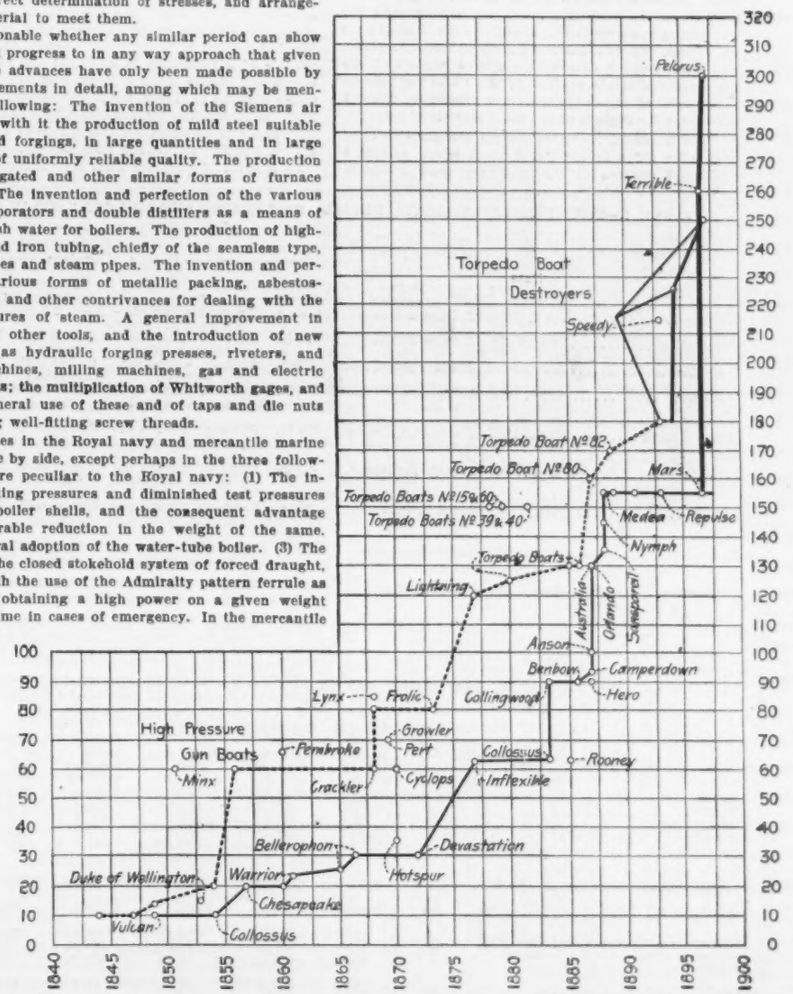

FIG. 2.—DIAGRAM SHOWING INCREASE IN BOILER PRESSURES IN THE BRITISH NAVY FROM 1844 TO 1897.

*Read at the International Congress of Naval Architects and Marine Engineers at the Imperial Institute, London, England.

†Engineer in Chief H. M. Navy. ††Chief Engineer Surveyor of Lloyd's Register of Shipping.

Fig. 3 shows the piston speeds which have been obtained in the Royal navy since 1860. A line has been drawn connecting the lowest examples, and it will be seen that there has been a steady general rise. By comparing the highest and lowest cases, i. e., the "Warrior," with a speed of 434 ft. per minute, and the "Starfish," with a speed of 1,221 ft. per minute, it will be seen that the piston speed had been practically trebled. Increased speed of revolution has been a most important factor in diminishing the size and weight of the engines, and in Fig. 4 these increases are indicated. The speed of revolution naturally varies with the speed, size, and draught of water of the vessel, and also the size of the engines.

In the figure the vessels have been arranged in classes following very closely their official classification, representative ships are selected and a line passed through them, special cases being shown by isolated spots. The lower line shows the battleships, and the "Bellerophon" and "Hercules" are notable cases of high speed of revolution for the time in which they were constructed, and in view of the size of the engine, the "Bellerophon" being 6,500 indicated horse-power, and the "Hercules" 8,500 indicated horse-power. The dash and dot lines on the diagram refer to the cruisers, which practically commenced with the "Inconstant" and the "Volage" in 1869. The earlier cruisers existed without much attempt at classification; later we find divergencies which eventually became accentuated into first, second and third classes, as shown by the three lines on the diagram. Vertical engines were fitted in the first-class battleships in 1875, and about 1887 the horizontal engine was abandoned generally for the vertical, the change being made practicable by modifications in the ship design, chiefly as regards protection. The stroke of the vertical engines was greater than the horizontal engines they replaced, and the revolutions were therefore less, though there was a slight increase in piston speed. A comparison of one of the twin engines of the "Mars" and the single engines of the "Warrior" shows that the speed of revolution has been practically doubled in battleships for engines of the same power.

In Tables I. and II. there are given a few particulars of representative ships in the Royal navy, which embodied the advanced practice at the time they were designed.

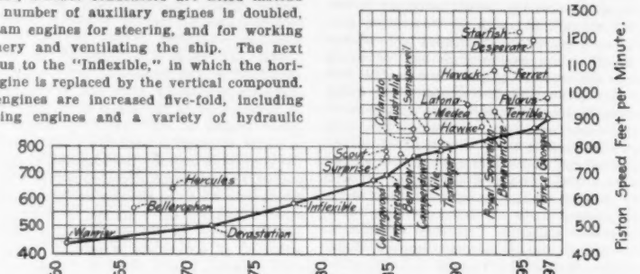

FIG. 3.—DIAGRAM SHOWING INCREASE IN PISTON SPEED IN THE BRITISH NAVY SINCE 1860.

chinery many now obsolete details, such as deadweight loaded safety valves, feed and bilge pumps worked off the main engines, cast-iron condensers; whilst the engines are started and turned by hand gear, and as first fitted there was no steering engine. There is also an entire absence of steel in the construction of engines and boilers.

Passing over a period of eleven years to the "Devastation," we find the engines are still simple, but twin screws have been adopted, surface condensers are fitted instead of jet, and the number of auxiliary engines is doubled, and includes steam engines for steering, and for working the gun machinery and ventilating the ship. The next six years bring us to the "Inflexible," in which the horizontal simple engine is replaced by the vertical compound. The auxiliary engines are increased five-fold, including hydraulic pumping engines and a variety of hydraulic motors driven by them for working the gun machinery. Steam-driven ventilating fans are freely used. The box boiler has disappeared, and its place is taken by oval boilers, some of which are double-ended. The engines are also fitted with piston valves. The expansion valve disappears at this stage, the "Inflexible" being so fitted originally, but the valves removed soon after her trials. We find another very important advance in this ship, the prelude of a revolution in shafting; for while her crank shafts and connecting and piston-rods are iron, the propeller shafting is of Whitworth compressed steel and hollow. As illustrating the advance which has been made in the matter of boiler preservation, it may be noticed that the "Inflexible" boilers are still efficient.

An interval of ten years from the "Inflexible" brings us to the "Sanspareil," and the advances here are again very marked. The compound engine is replaced by the triple expansion. Steel replaces iron generally for shafts, rods, columns, and also for the main bearing frames, and the crank and propeller shafts are hollow throughout. The boiler pressure is more than doubled. The boilers are entirely of steel, with corrugated furnaces. The piston speed is increased nearly 50%. Cast-iron pistons are replaced by cast-steel in the case of the low-pressure and intermediate pressure pistons, and arrangements for forced draft are fitted. The number of auxiliary engines has increased to ninety-two, and their indicated horse-power to 2,100. The feed-pumps are no longer worked off the main engine, evaporators are fitted for making up loss of fresh water and in the construction of the condenser cast-iron is replaced by gun-metal.

The advances of the nine years succeeding the "Sanspareil" are best seen by comparing that ship with the "Terrible." The boiler pressure in the "Terrible" is nearly double that in the "Sanspareil;" and, although the figures in column marked with an asterisk do not indicate any reduction in weight, it must be remembered that while the "Sanspareil's" power was obtained by a liberal use of forced draft, the "Terrible's" was obtained without any air pressure, the stokeholders being open, and by comparing the "Terrible" with the "Sanspareil" under the same conditions as in column marked †, we have a reduction in weight per indicated horse-power in favor of the "Terrible" of over 35%. The reduction in weight from

TABLE I.—GIVING CHARACTERISTIC DETAILS OF ENGINES AND BOILERS USED IN REPRESENTATIVE ENGLISH WARSHIPS FROM 1861 TO 1897.

Ship.	Date of trial of machinery.	Maker of engines.	Details of engines. Screw.	Type.	No. of cylinders.	Diameter, ins.	Stroke in ft. ins.	No. of revolutions.	Piston speed.	I.HP.	Air press., stokebld., ins.	B'ler press., lbs. per sq. in.	Description of boiler.
Warrior	Oct., 1861.	J. Penn & Son.	Single.	Jet condensing, simple hors'nt'l trunk.	2	112	4 0	54.25	434	5,469	Nil.	22	Rectangular iron.
Devastation	Oct., 1872.	J. Penn & Son.	Twin.	Surface, simple horizontal trunk.	4 (2 to each engine.)	80	3 3	76.92	500	6,652	Nil.	30	Rectangular iron.
Inflexible	Nov., 1878	J. Elder & Co.	Twin.	Surface, compound, vertical.	6 (3 to each engine.)	2 of 70 4 of 90	4 0	73.26	586	8,483	Nil.	61	Oval, single & dble-ended, iron.
Sanspareil	Sept., 1888	Humphrys, Tennant & Co.	Twin.	Surface, triple-expansion, vertical.	6 (3 to each engine.)	2 of 43 2 of 62 2 of 96	4 3	100.73	856	14,483	2	135	Circular, angle-ended, steel.
Prince George	Sept., 1896	Humphrys, Tennant & Co.	Twin.	Surface, triple-expansion, vertical.	6 (3 to each engine.)	2 of 40 2 of 59 2 of 88	4 3	101.8	865	12,280	1.25	155	Circular, angle-ended, steel.
Terrible	Jan., 1897.	J. & G. Thompson.	Twin.	Surface, triple-expansion, vertical.	8 (4 to each engine.)	2 of 45 2 of 70 4 of 76	4 0	112.0	896	25,648	Nil.	260	Belleville water-tube.
Ferret	Oct., 1894.	Laird Bros.	Twin.	Surface, triple-expansion, vertical.	6 (3 to each engine.)	2 of 19 2 of 29 2 of 43	1 6	360.08	1,080.24	4,474	4.1	175	Normand watr-tube
Janus	Nov., 1895	Palmers.	Twin.	Surface, triple-expansion, vertical.	6 (3 to each engine.)	2 of 18 2 of 27½ 2 of 42	1 6	367.1	1,101.3	3,789	2.48	210	Reed's water-tube.
Desperate	Sept., 1896	Thornycroft.	Twin.	Surface, triple-expansion, vertical.	8 (4 to each engine.)	2 of 20 2 of 29 4 of 30	1 6	397.6	1,193.8	5,796	3.5	215	Thornycroft's water tube.
Quail	Jan., 1897.	Laird Bros.	Twin.	Surface, triple-expansion, vertical.	6 (3 to each engine.)	2 of 21 2 of 32½ 2 of 48	1 6	367.2	1,101.6	6,057	4.77	220	Normand watr-tube

TABLE II.—GIVING WEIGHT OF MACHINERY, EFFICIENCY OF MACHINERY PER TON AND COAL CONSUMPTION PER INDICATED HORSE-POWER IN REPRESENTATIVE ENGLISH WARSHIPS FROM 1861 TO 1897

Ship.	No. of Boilers.	No. of Auxiliary engines.	Approximate I. HP. of all auxiliary engines.	Weight, in tons, of: Machinery and boilers, water at working height.	Engines, main and auxiliary.	Boilers with water at working height.	Water in boilers at work'g height.	Water in 1 boiler at work'g height.	I. HP. per ton of: Engines.	Boiler.	Water in boilers.	Coal per I. HP.
Warrior	10	8	350	898.2	421.63	476.6	171.7	17.17	12.97	11.47	31.87	3¾ to 5.
Devastation	8	16	880	971.95	484.2	487.7	125.8	19.1	13.73	13.64	52.87	3.12 to 4.42.
Inflexible	12	82	1,400	1,366.4	654.2	712.2	187.38	18.56	12.96	11.9	45.27	2.38 to 2.74.
Sanspareil	8	92	2,100	1,089.36	509.19	581.1	132	18.8	*28.44 †15.85	*24.96 †13.87	*109 †61.14	1.88 to 2.6 (according to speed and quality of coal).
Prince George	8	146	2,800	1,326.59	623.8	702.7	165.2	20.65	*19.7 †16.77	*17.33 †14.89	*74.33 †63.34	1.82 on 30 hours' trial at 50% of full power.
Terrible	48	80	2,900	2,224.78	1,076.4	1,148.3	48.75	1.06	23.8	22.3	526.1	1.71 on 30 hours' trial at 74% of full power.
Ferret	4	19	150	123.61	59.4	64.1	11.48	2.87	75.2	69.7	389.7	2.3 at 11 knots.
Janus	4	20	170	120.0	49.0	70.69	7.95	1.99	77.3	53.6	477.0	2.5 at 13 knots.
Desperate	3	18	230	127.95	61.49	66.46	7.75	2.58	94.3	87.2	747.0	2.5 at full speed. 1.67 at low speed.
Quail	4	17	230	144.3	68.6	75.7	11.25	2.81	88.4	80.1	539.0	2.64 at full speed. 1.64 at low speed.

* These figures for indicated horse-power per ton given are based on the forced draft power. † These figures are based on the natural draft power.

Some torpedo boat destroyers are added, as the machinery of these little vessels represents with the single exception of the steam pressure employed, what is most advanced in modern marine engineering. The "Warrior" was launched in 1860, and tried in 1861. She has been since reboilered, but the original engines are still efficient. Besides the general features already mentioned, we find in her ma-

the "Prince George" is seen from the table, but in this ship again the maximum power was obtained with forced draft. Taking the natural draft power of the "Prince George," there is again a reduction of weight in favor of the "Terrible" of 33%. In the "Terrible" we have, besides water-tube boilers, many improvements in detail necessary in order to deal with the high-pressures

with certainty. Among these may be mentioned a general use of steel steam pipes, and of metal to metal joints, also of asbestos-packed cocks and metallic packings. There are also improvements for dealing with the water from the air-pumps, and for extracting grease from the same, and a large increase of capacity in the plant for supplying fresh water. One of the most important features is the large reduction in the weight of water carried in one boiler, a matter of considerable moment in case of damage in action or failure of any part when under steam. The small amount of total water carried in the boilers is also noticeable, making it, with the arrangements supplied to the "Terrible," an easy matter to run the boilers always with distilled water if desired.

A comparison of the torpedo-boat destroyer "Quail," with the "Warrior," suggests itself on account of the indicated horse-power of the two vessels being so nearly the same, and because of their positions at the beginning and end of the period under consideration. The weight of the "Warrior's" machinery only would more than supply two complete "Quails," hull and machinery, with crew and stores equipped for sea. While, if the weight of the "Warrior's" machinery were turned into machinery of the "Quail" class, it would supply 38,000 I. HP. instead of 5,400 with a coal consumption per indicated horse-power of half that of the "Warrior."

In the mercantile marine the advance of engineering has been steady and continuous. In the majority of cases economy of coal has been, as it always will be, the predominating factor affecting the design, and the progress made in this direction has, no doubt, been the principal

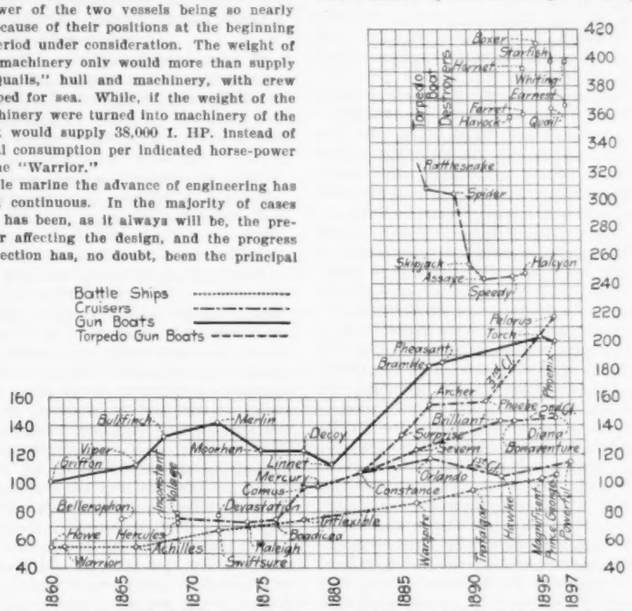

FIG. 4.—DIAGRAM SHOWING INCREASE IN THE SPEED OF REVOLUTION IN THE BRITISH NAVY FROM 1860 TO 1897.

reason of the great development in steam shipping, both in point of numbers and in size of vessels engaged in general commerce, while it has rendered it possible for them to compete in trades previously monopolized by sailing vessels.

EFFICIENCY OF SMALL RECIPROCATING PUMPS.

The report of the Board of Irrigation Survey and Experiment of the State of Kansas, for 1895 and 1896, contains an interesting paper by Prof. O. P. Hood, of the State Agricultural College, on tests of small, single-acting pumps used in connection with windmills for irrigation purposes. A novel feature of the tests was the means used for measuring directly the power applied to the pump rod. It was designed and constructed by Prof. Hood, who calls it a reciprocating dynamometer, and it is described as follows:

As a part of the pump-rod, a movable piston was placed, so connected that when the rod was in tension the piston was forced into its containing cylinder. In the cylinder, oil was placed. Oil being practically incompressible, the piston would not move when the rod was subject to tension unless an outlet was provided for the compressed oil. The oil would be under a pressure corresponding to the tension of the rod. The oil was allowed to exert its pressure upon the piston of a Crosby steam-engine indicator, the movement of whose small piston was opposed by a spring of known resistance. The area of the dynamometer piston was 5 sq. ins.; that of the indicator, ½-sq. in. The maximum movement of the dynamometer piston was .04-in., which represents the lost motion in the pump-rod. To enable this device to measure compression as well as tension in the pump-rod, it was necessary to supply an initial compression on the oil by means of a spring forcing the piston into the cylinder. The spring furnished an initial compression on the oil and the corresponding position of the indicator pencil represented zero stress on the pump-rod. Any tension in the rod was recorded by the raising of the pencil due to the greater compression of the oil, while any compression in the rod was recorded by a lowering of the pencil due to a reduction of the initial compression of the oil caused by the spring. The indicator drum carrying the record paper was given a reduced motion corresponding to the pump-rod. The record drawn by the indicator gave the stresses in the pump-rod at each part of the stroke, with no device using power between it and the pump.

The tests were made at the Kansas State Agricultural College. The pumps were operated from a line shaft placed 40 ft. above the well which supplied the water. A Flather hydraulic recording transmisson dynamometer acted as a countershaft between the line shaft and the pump rod, the dynamometer shaft carrying a pinion which drove a gear on which was an adjustable crank pin. The crank pin drove a connecting rod, which, through a crosshead, drove the pump rod. The record of the Flather dynamometer gave the power necessary to run the whole machine, including the two gears, crank pin, connecting rod and cross-head, together with the pumps. This record was used as a check upon the record of the reciprocating dynamometer in the pump rod. The latter record was used in plotting the results of the tests.

The pumps tested were the following: One 8-in. cylinder, 10-in. stroke, built by Mr. H. P. Van Voorhis, of Topeka, Kan.; a 4-in. common pump cylinder, an 8-in. irrigation cylinder, and a 3-in. deep well cylinder made by the Mark Mfg. Co., Chicago; and 3-in., 4-in., 5-in. and 6-in. cylinders of the Frizell pattern, furnished by the Crane Co., Chicago.

The results of the tests are given in Prof. Hood's paper in detail, with the tables and diagrams. His conclusions are given in the following summary:

So far as the tests go, the following is shown:

1. The efficiency of pumps, all having a right to be called good pumps, may vary from 20% to 85%, depending on the lift and piston speed.

2. A fall of 25% in the efficiency of a pump in the usual range of windmill speeds is not uncommon.

3. A pump having a variation of only 5% is possible.

4. For wells about 20 ft. deep there is no need of using a pump of less than 75% efficiency for average speeds.

5. Two pumps may compare very favorably at a certain lift and much less favorably at some other lift not very much different.

6. A pump having an efficiency of over 80% at piston speeds up to 100 ft. per minute is possible at a 20-ft. lift.

7. Some pumps can be run at a piston speed of 180 ft. per minute and maintain an efficiency above 70% for lifts above 20 ft.

8. A pump with very large clack valves on a very low lift may give an efficiency from 80% at slow speed to 50% at a piston speed of 80 ft. per minute.

9. Pumps at slow speed and high speed discharge a little less water per stroke than at medium speed. This may be from 1 to 2%.

10. A pump with small delivery pipe may at high speed deliver a considerably larger amount of water than that computed from the cylinder capacity.

11. With pumps having an ample supply of water, the speed may be limited by the failure of the lower valve if its movement is not limited.

12. Valves of limited movement are preferable for fast speeds.

13. The addition of a stuffing-box to any form of pump may seriously reduce the efficiency.

14. The initial stress on the up-stroke at higher speeds is the destructive element on the windmill. The use of a device to reduce this is well worth consideration. At piston speed of only 70 ft. per minute, this sudden jerk may be two or three times the weight of the column of water lifted.

THE UTILIZATION OF WATER flowing from the Periyar Lake, in India, is proposed, and the government is advertising for proposals for utilizing this water for purposes other than irrigation and not incompatible with the use of the water for drinking. The irrigating season extends over nine to ten months, during which time the discharge is likely to be from 1,100 to about 500 cu. ft. a second, according to the demands for irrigation and the available quantity in the lake. Subject to the risk of interruption by accidents or drought, a supply can be given throughout the irrigation season. No supply can be guaranteed at other times, but, so long as the water is available, the government will be prepared to issue it in such daily quantities as may seem to it advisable with reference to the time which is likely to elapse before the supply is replenished by the setting in of the rains. The fall from the tunnel to the foot of the hills is approximately 900 ft., and the distance measured along the course of the stream about 6,800 ft., and 1 cu. ft. per second falling 900 ft. is estimated to produce over 60 effective horse-power. Intending lessees should state the quantity of water required in cubic feet per second, and the annual rent offered for each cubic foot per second. No rent will be charged for the first year from the date of the concession; for the second year the charge will be one-fifth, and an additional charge of one-fifth will be made every year until the full rent is reached. Lessees will construct at their own expense, on plans to be approved by government, all the weirs and other works required to divert the water from the river below the tunnel. Further information can be obtanned from th Chief Engineer of Irrigation, Madras, India, who will receive bids up to Oct. 31. The dam and reservoir have been described in our columns, and various plans have been proposed to utilize the overflow for power purposes.

THE METRIC SYSTEM is the subject of a strong report prepared by Gen. Stone, Chairman of the House Committee on Coinage, for presentation to the next Congress. He advocates the adoption of the metric system of weights and measures by the United States. By tables prepared by the Treasury Department, he shows that we have commercial relations with nations occupying the following position upon the metric system:

	Population.	Imports.	Exports.
Total obligatory metric system	..254,318,829	344,270,432	277,224,066
Total legalized	3,476,000	2,700,922	1,272,080
Total permissive	83,686,518	191,659,728	399,961,407
Total nonmetric	118,155,901	12,626,393	15,283,403

In this list England practically covers all of the permissive class, excepting Japan, which still uses a mixed system, gradually passing into the metric. Turkey is also of the permissive class, as the law is not enforced. Russia and Denmark are classed as nonmetric, though the metric system has been introduced in Finland, and is made absolute throughout Russia, since Jan. 13, 1895, for the preparing and dispensing of medicines. In Denmark the metric system is permitted and largely used. The population of the metric-using nations is now 445,286,000, according to the figures of the English Metric Committee. This practically includes all the civilized world, excepting Great Britain, Russia and the United States. In the new bill prepared by Gen. Stone it is provided that after July 1, 1898, the metric system of weights and measures shall be exclusively used in all operations by the government, except in completing the survey of the public lands. After Jan. 1, 1901, the metric is to be the only legal system of weights and measures recognized in the United States. Gen. Stone explains that this does not prohibit the use of any other standards of weights and measures, but simply proposes to establish certain legal standards to which reference may be made in case of dispute; and it proposes that this standard shall be common with the recognized standard of every nation in the world excepting the three mentioned. Gen. Stone also declares that the adoption of the metric system would assist American manufacturers and merchants in extending their trade with metric-using nations.

NAVIGATION FROM TOLEDO, O., TO CHICAGO, ILL., has been effected by the naphtha launch "Dauntless," owned by Mr. Webber. The boat is 26 ft. long and 5 ft. beam, and carried three men. The route was by the Maumee River and Miami Canal to Cincinnati, thence by the Ohio River to Cairo, and up the Mississippi and Illinois rivers and Illinois & Michigan Canal to Chicago.

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This journal is in constant receipt of letters from engineers and others seeking employment on prospective Chinese railways, and many of these letters are directly chargeable to the communication of Mr. Van Bergen, published in our issue of April 29 last. This letter has brought out the very full and satisfactory explanation of the actual railway situation in North China, contained in the present issue, and we recommend the correspondents first mentioned to study it carefully, as a full reply to their queries. Our correspondent is personally known to us as a very competent and intelligent engineer, long resident in China, and in a position to know of what he writes. Notwithstanding the frequent press accounts to the contrary, the prospects for success, of the several American syndicates working in China, are anything but promising. Chinese methods and the pressure of interested European powers upon the Chinese, are evidently too strong for the best-laid plans of the American representatives in the Flowery Kingdom. As our correspondent remarks, the policy of the United States government towards the Chinese is not calculated to make friends among them; and as we are not in a position to coerce them, as are Russia and France, any present dealings with them must be the result of very considerable pecuniary sacrifice. By sending well-equipped representatives to China, and by vigorously combating the established trade with England, Germany and France, we may in time—and doubtless will—open a market for railway supplies and many goods of American manufacture. But such a trade will be slow at first and will only be established on its merits and as the result of hard work by well-trained and adroit representatives. Meanwhile, if any money is to be made out of the actual construction of the roadbeds of the proposed railways, we may rest assured that the Chinese Mandarins, who usually secure the supervision of this work, will not let the pecuniary profits escape them. With their power, love for the dollar, absolute control over labor, and with the prices prevailing for labor and construction work performed, little would be left for the foreign syndicate. The only exception to this rule would result from the power to bring pressure upon the Chinese officials and compel a division of the spoils, and this power is in the hands of rival European nations. And lastly, we fully agree with our correspondent that it would be worse than useless for any American engineer to go to China with the idea that lucrative employment, or employment of any kind, could be had for the asking, after he got there. The conditions of to-day are all against his success. What may happen in the future is another story; but it would be wisest to await developments.

While the markets of South and Central America lie at our door and the manufacturers of the United States should have advantages in location and in facilities for making goods suitable for these markets, our trade in that direction is relatively small, and English, French and German producers supply the wants of these countries. Much of this lack of trade is due to the fact that American goods are practically unknown in many sections of South America, and our manufacturers are without direct representation there. The European countries named, on the other hand, have establishments in every principal trade center in the South American States, where their goods are carried in stock and can always be seen and examined by intending purchasers, and expert agents, trained in the language and the wants of the people, efficiently assist in developing trade. This businesslike method of building up a foreign commerce has as last been recognized by American manufacturers, and a serious attempt is being made to improve upon past conditions. The National Association of Manufacturers of the United States, with headquarters in Philadelphia, has now completed arrangements for establishing, at Caracas, Venezuela, a sample warehouse for the permanent exhibition of American goods. The government of Venezuela has manifested its friendly disposition towards the enterprise by admitting these goods free of duty, until actually sold, and has granted other valuable privileges; and one of the New York steamship lines will carry these exhibits to Caracas for one-half the usual freight rate. This warehouse is not intended in any way to compete with the export companies now handling the bulk of the existing trade between the United States and Venezuela. Its purpose is solely to bring new wares to the attention of possible buyers, and thus to expand our trade with that country. The charge for space is a nominal one, ranging from $2 to $5 per square foot annually, and the establishment is organized so as to be simply self-sustaining, without any direct profit to the Association other than what may accrue to its members from goods sold.

This Caracas exhibition is a first step in a direction that has greatly profited other nations; and if the opportunities presented are taken advantage of by American manufacturers to the extent that they should be, it will encourage the establishment of similar exhibition warehouses in other South American and foreign trade centers. It is a thoroughly sensible and businesslike method of securing trade with these peoples and is proven in efficiency by the success attending its application by other nations. But our producers should not forget that while the simple exhibit of new goods may attract purchasers, agents expert in the methods and needs of these foreign trade centers are even more necessary. In fact, without these efficient agents, no permanent trade can be developed; for foreign competitors are now on the ground to explain away any differences in goods, and personal effort in opposition can only be met by equally active and intelligent personal work on the part of American representatives.

It might also be noted here that the development of Brussels as a trade center for the introduction of American labor-saving machinery in all branches of industry is being attempted under the direction of Col. Charles J. Murphy, formerly special commissioner of the U. S. Department of Agriculture in Europe. Col. Murphy has been very successful in introducing American agricultural products to European consumers, and he has now secured ample space in one of the largest and most attractive stores in Brussels for the permanent exhibition and sale of American goods. It is proposed to handle nothing but manufactures and machinery of the highest grade, and the exhibits already include electrical apparatus of various kinds, stoves, sewing machines, bicycles, safes, typewriters, steam engines and boilers. As the International Exhibition is now open in Brussels, and this will undoubtedly attract large numbers of possible buyers, the time and place for exhibiting American machinery and other products are evidently well chosen. The city of Brussels is exceedingly well adapted for a permanent exhibition of this character, as it is near the ports of Antwerp and Rotterdam; it is directly on the line of railway distribution to all parts of Europe, and is itself on neutral ground, where German, French and English traders meet in friendly rivalry.

The appointment of the new Nicaragua Canal Commission by the President promises little additional light upon the real engineering features of this important project, though an examination of and a report upon the project from the standpoint of engineers is supposed to be the purpose of their appointment. One member of the commission is a military attache at a foreign court, and, according to press accounts, has sailed for this post of duty. Yet this board is supposed to visit Nicaragua, examine into the engineering possibilities of an enormous project, surrounded by difficulties of a very unusual nature, and to prepare a report before the next session of Congress in December. Any report that can be submitted in this time and under the conditions imposed will simply be worthless. Then, too, as the doubtful engineering features of the project are alone supposed to call for the personal investigation of a commission in Nicaragua, what place has Admiral Walker upon such a commission? He is an excellent naval officer, doubtless, but he certainly is not an engineer, and his expressions of opinions upon technical questions will carry no weight whatever. Capt. Carter is an engineer of unquestioned ability and long experience; but he is seemingly so situated that he can give but little time to the consideration of the Nicaragua Canal. Prof. Haupt is an engineer, well known by his many contributions to canal literature, and his work as an expert. But Prof. Haupt is also known by his writings to be a strenuous advocate of ship canals everywhere, and under almost all conditions, and he goes to his work on the Nicaragua Canal decidedly prejudiced in its favor.

This is not the kind of a commission wanted by the people of the United States, and especially by the engineers of this country, for the consideration of so important an engineering project. The late commission was a better one, in so much that it was composed entirely of engineers of decided reputation; and if their work was not satisfactory, that of the present commission will be less so. If the United States government really needs a thorough, intelligent and satisfactory digest of the engineering possibilities of a ship canal across Nicaragua, as a preliminary to any national action in the matter—and we think it does—it must go about it in a very different manner and employ very different material. The only trouble with the canal to-day is that the project as a whole has never yet been investigated by and reported upon in all its features by engineers of the reputation and tried ability called for by the exceedingly important character of the work. Much good preliminary work has been done in Nicaragua; but the report of the last commission is sufficient proof that much of such work yet remains to be done before sufficient data are available upon which to base a report that will be both convincing and unassailable, from a technical, as well as a popular point of view. Before taking any decided steps in a like enterprise a foreign government would have submitted the whole problem to a board of the most eminent engineers that the country could furnish, and this board would be provided with all the means and time that an exhaustive and thoroughly satisfactory examination would demand. Questions of diplomacy can best be settled by the home government and need no commission abroad; and with these discussed and the final report of able engineers available, the question of national aid, or of national condemnation of the scheme could be speedily settled. In an enterprise prob-

ably costing a hundred millions, the necessary expenditure of time and money to secure the kind of a report needed is but a small percentage of the whole, and the outlay would be wise. The United States government has already wasted several years and a considerable amount of money on this enterprise, with exceedingly unsatisfactory results; and its latest effort in this direction will add practically nothing to the status of the canal as a desirable national undertaking. Would it not be well now to try some other plan; and either assume the canal with all its doubtful quantities and plans, leaving these to be adjusted and elaborated in the future at any cost; or to put off still further the day of consideration of the project, until the final location, fully digested plans and a thoroughly reliable estimate of probable cost could be prepared. And if the latter plan should ever be adopted, let the government select an engineering board and provide an equipment that will leave no room for question as to the experience and ability of the members of the board and the absolute reliability of their final report.

MODERN IMPROVEMENTS IN MARINE ENGINE PRACTICE.

The paper on the progress of marine engineering in the British navy and mercantile marine, which is published in abstract elsewhere in this issue, is an unusually clear and forcible presentation of the forces which have given us the "ocean greyhounds" and "commerce destroyers" of to-day. We question whether, among the dozens of articles describing the great naval review at Spithead, on June 26, one can be found which portrays the advance made in ship construction and marine steam engineering during the past 40 years more clearly than this paper. Indeed, its appropriateness to the occasion makes it more than presumable that its authors had the Jubilee naval celebration in mind when they wrote it. The paper, however, will appeal to American engineers more because of the high standing of its authors, and because of its clear manner of presenting facts, which makes it easily intelligible to engineers who have engaged in other branches of the profession and to whom the finer technicalities of marine engineering practice are not always familiar.

In the condensed form in which we present the paper it is so wholly a terse statement of facts, that it will prove helpful to examine somewhat further the broad general bearing and significance of the more important of them. It will be evident, of course, that this can be done only in a very brief and somewhat hap-hazard manner within the limits of our space. As far as possible, also, the repetition of information already given in the article and accompanying tables and diagrams will be avoided.

The three great improvements which the last 40 years have seen developed in marine engineering are increased economy in fuel consumption for a given amount of power generated, a reduction in the weight and size of boilers and engines, and a change in the material of construction of the hull, first from wood to iron and then from iron to steel. The bulk of the first two of the advances mentioned has taken place in a little more than 20 years. Broadly speaking, the increase in fuel economy has been due to the expansive use of steam, while space and weight of machinery have been reduced by the change from flue to tubular boilers, and, in the engines, partly by the change of type and partly by using higher pressures and piston speeds and greater speeds of rotation. A glance at the diagrams published with the paper elsewhere will show how these factors of steam pressure, piston speed and frequency of rotation have developed.

Leaving a more particular consideration of the improvements just mentioned to be taken up later, it is instructive to notice first the growth as a whole in the use of machinery in ocean vessels. In studying the tables for this purpose we may well select for comparison the typical vessels chosen by the authors of this paper, viz., the "Warrior," "Inflexible," "Sanspareil" and "Terrible." As their names are almost enough to show, these are all war ships. What is true of them, however, is true, with limitations which will naturally suggest themselves, of merchant craft for transporting freight and passengers. Perhaps no one thing is a better indication of the increased use of machinery in ships than the large number of auxiliary engines employed. Each increase in the number of these motors means that something which was formerly done by hand is now done by machinery, or else that duties which once did not exist on shipboard have grown up and require power for their performance. Between the construction of the "Warrior" and "Terrible" the use of auxiliary engines has increased nearly ninefold, both in the number of engines and in the amount of power which they supply.

In every instance it is manifest that these auxiliary engines have to be supplemented by other machinery for transforming their power into useful work, and of course these various devices all count in the general machinery equipment of the vessel. The character of this auxiliary machinery is, it is plain, far different in merchant and war vessels, and it is also more extensive in the latter craft, but the ratio of increase in its use has probably been as great in the modern Atlantic liner as in the fighting ship. Very frequently this fact is not fully appreciated. Most people look upon it as a natural enough thing that a vast array of powerful and intricate machinery should be necessary in a war vessel, and in its contemplation they forget that in its own way the fast passenger ship is quite as perfectly supplied. A brief consideration of the fact, however, that for two-thirds of the time these vessels are floating communities supplying from within themselves the daily needs of a thousand or more people almost as fully and perfectly as a great city hotel, should correct any misapprehension as to their relative development in this regard as compared with war ships.

It is a common thing to hear a modern war vessel spoken of as a "floating machine shop." In the minds of many there is probably an element of facetiousness in this expression. It assumes, however, a very real meaning when one comes to examine into the matter a little. About as great a variety and as high types of modern machinery for generating and applying power are found in a war ship or an Atlantic liner as can be found in almost any other single work of mechanical engineering. It is quite plain, too, why this should be the case. Within pretty wide limits in fast passenger ships cost is a secondary consideration to questions of speed and ease of operation and to the necessity of providing conveniences and comforts to passengers, while in the war vessel cost may be said to be subordinate always to anything which will aid in securing a better fighting instrument.

It will be understood, of course, that in the improvement of marine engine practice, neither space nor weight has decreased absolutely, but only relatively, that is, in proportion to the power developed per ton of machinery. A glance at the tables will show that the engines and boilers of the "Terrible" weigh nearly three times as much as those of the "Warrior," but that per ton of weight they develop twice the power. It will be noticed also how largely responsible the water-tube boiler has been in reducing the weight of the steam generating machinery. Coupled with modern distilling apparatus the weight of water necessarily carried in the boilers has been reduced from 172 tons in the "Warrior" to 49 tons in the "Terrible," or over two-thirds.

It is somewhat curious to recall that the water-tube boiler, which is now almost universally used in naval craft of modern design, was tried by the British navy as early as 1857, and then abandoned for nearly 25 years, and finally taken up again in the beginning of the eighties. The chief reasons for discontinuing the use of these types of boilers after their first trials were imperfections in their design—the circulation in the tubes was poor and cleaning and repairs were difficult on account of their inaccessibility—and the fact that such pressures as were used with the engines of that time could be obtained easily with flue boilers. The need of higher pressures for the expansive use of steam in triple and quadruple cylinders was thus largely responsible for the reintroduction and development of the water-tube boiler in the navy. Of course other advantages which they presented for naval use also had much to do in securing their general adoption, among which their lightness and small weight of water carried and the rapidity with which steam can be raised are important.

Despite their universal use in the navy, however, water-tube boilers have not gained general favor for merchant vessels. To explain in detail the reasons for this would involve too long a discussion of technical questions, but summed up briefly they are, first, that the qualities which make such boilers especially valuable for war vessels are not so much demanded in the mercantile marine, and second, that they are generally regarded as more difficult to keep in order and less durable than the Scotch boiler commonly used. These objections are, it may be noted, vigorously disputed by the advocates of the water-tube boiler for merchant vessels. This controversy, however, need not be considered here any further than to suggest that the possibilities for improvement in water-tube boilers are by no means exhausted, and if the faults mentioned are true now it by no means follows that they will always remain true.

Economy of space and weight in marine engines has resulted partly from the change to the vertical direct-acting engine, but more from the use of higher steam pressures and greater speeds of revolution. The reason for this is easily understood. With a cylinder of given diameter and stroke the power developed in it will depend upon the product of average pressure and the number of revolutions. As shown clearly by the diagrams, both of these factors have increased in a remarkable degree.

Economy in fuel consumption has likewise been due mostly to the constant increase in steam pressure and increased expansion. Of course, the increased expansion and the improved arrangements for carrying it out are the real causes of the economy, the higher pressure being merely a necessary condition of greater expansion. Roughly speaking, the present rate of fuel consumption for a given power is about from one-fourth to one-fifth of what it was 40 years ago, and one-half of what it was 25 years ago. As in stationary engine practice this advance in fuel economy has been due more to improvements in engine design than to better boiler practice, especially during the last ten years.

In contemplating the gains which have resulted to marine engine practice through the expansive use of steam, it is important not to overlook the fact that the high steam pressures necessary for multiple expansions have been made possible very largely by the invention and improvement of processes and machines which have given engineers better structural materials and more perfect workmanship. The most striking advance in these respects has been, of course, the production of cheap and reliable steel plates and forgings, and of the powerful machinery necessary to manufacture them. Invention has in addition been very prolific in special devices, and a number of the more important of these have received deserved mention in the paper which we reprint. The study of this paper will afford many additional suggestions for thought to those who may be interested to follow the subject further, but space need not be taken to develop them here.

A question which naturally suggests itself in reviewing what has been said is, what will the future give us in the way of further improvement in marine engine practice? Are steam pressures, piston speed, and speed of revolution to go on steadily increasing as they have been doing in the past, or will some other line of improvement be developed? As far as pressure is concerned there are certainly serious practical objections to a much further increase, that perhaps some day may be overcome, but at present are very valid. When steam pressures of 250 lbs. and above are reached it becomes an increasingly difficult problem to take care of the high pressures and temperatures; packing, lubrication, expansion, danger from explosion, leakage, condensation, all become troublesome to control satisfactorily. Finally, with increasing pressures an increasing number of cylinders will be required for the best use of the steam expansively. It is possible, as just stated, that these

questions will all be answered in due time, just as they have been in the past, but at present there seem to be pretty serious difficulties in the way. In mercantile vessels particularly, saving in wear and tear, freedom from breakdown and delay, and various other commercial considerations soon reach a point where they count for more than speed or economy in fuel. In the navy these considerations are not so important, but still they have their bearing there also.

The rate of rotation and piston speed on their part also present difficulties to further increase. Speed of rotation is involved with questions of propeller and general ship design that make it difficult of simple discussion, but it may be stated that present practice has set a limit not very far ahead beyond which neither piston speed nor speed of revolution are considered advisable. There seems, therefore, to be much reason to think that within the next few years an emphatic turn to the right may be expected in the curves of the diagrams published elsewhere.

In conclusion, attention may be called to the little diagram published with the paper, which shows the growth of the effective horse-power of the ships in the British navy since 1860. Until 1885 it will be seen that it remained in the neighborhood of 500,000-HP., but since that time it has rapidly increased until now the total horse-power of war vessels built and under construction is 2,500,000-HP., or nearly five times as great as in 1885. It is rather an interesting speculation as to how long Great Britain, and other nations as well, will go on increasing their expenditure in war ships, and it is also rather a satire on common sense to know that there is almost no practical knowledge of how well any of these vessels will serve their purpose in actual battle.

LETTERS TO THE EDITOR.

The Attitude of the Board of Examiners of the New York Department of Buildings Toward Fireproof Floors.

Sir: In your issue of July 15, Mr. Gus. C. Henning attacks my position as a member of the Board of Examiners of the New York Building Department, with reference to patent composite fillings for floors as substitutes for arches of brick or of sectional hollow brick of hard burned clay or porous terra cotta. It is true that I differ with Mr. Henning in believing that the patent substitute floors are not so good as those specified in the law, but modesty prevents my claiming any more for my opinion than that I prefer to be guided by it rather than by Mr. Henning's, and assume that the New York Board of Fire Underwriters, whose delegate I am to the Board of Examiners, wish me to vote in line with my opinion rather than in accord with somebody else's.

With reference to attending the floor tests, I observe that Mr. Henning takes me to task for my absence. I was not under obligation, legal or otherwise, to attend these tests. They were not official, but conducted by private parties. It happens, however, that I did send an expert in the employ of the Insurance Company with which I am connected and am not uninformed with regard to the results. I have already stated that I have observed that these materials, concrete, etc., are prepared for tests with much greater care than for installation in buildings.

I will add that the Pittsburg experience with the two forms of construction does not indicate anything whatever as regards their relative fireproof qualities, since the tests to which they were subjected were not uniform, the conditions not being the same.

Mr. Henning takes me to task for claiming that weight contributes to stability against lateral wind pressure. Mr. Henning will have succeeded in establishing new theories of statistics and dynamics when he proves that weight is not necessarily a factor in computing resistance to wind strains.

I note in your editorial, based upon Mr. Henning's communication, that you say the weakest point of my position is "not the absolute safety of concrete floors, but the relative safety of floors of concrete and floors of tile." I assume that, after stating my preference for the floors of tile, you will now hold my weakness to be one of opinion and not of neglect to state the fact. And here I let the matter rest, so far as I am concerned, without imposing further upon you or your readers with argument.

Very truly yours, F. C. Moore.

46 Cedar St., New York city, July 16, 1897.

The Actual Railway Situation and the Alleged Opportunities for American Engineers in China.

Sir: Yesterday, at the Yamen of H. E. Li Hung Chang, I was shown a letter to His Excellency from an American engineer asking for work in China. The letter contained a clipping from Engineering News of April 29, 1897, written by R. Van Bergen, Esq., of Shanghai, under the heading of "Opportunities for American Engineers and Railroad Builders in China." In this letter there are many statements that are not intentionally incorrect, but which will be very misleading to American engineers as to the true railway situation in China. I was requested to write you a plain statement of the case, and therefore send you the following, which will, I hope, explain clearly the actual situation of to-day. What it may be to-morrow, next week or next month, "is one of those things that no fellow can find out:"

The railways of China that are constructed and in operation are as follows: Tientsin to Tong Ku, the mouth of the Pei Ho, and the head of steamer navigation for the last two years, as the river between Tung Ku and Tientsin is silting up very rapidly. Tung Ku to Shan Hai Kwan, which is the point where the Great Wall runs into the sea, and from Shan Hai Kwan north towards Manchuria, about 60 miles. This line, as far as Shan Hai Kwan, was in operation before the Chinese-Japanese war. The total length is about 185 miles, from Tientsin to the Great Wall. Within the last eighteen months a line has been completed from Tientsin to near Peking, 80 miles long, and a few trains are now running with regularity. There is one short piece of railroad at the iron works on the Yangtze River for conveying ore to the furnaces. The above constitutes the entire railway system of China as it now exists, and, with the exception of the small line at the iron works, it is known as the Imperial Chinese Railway of North China.

It is purely and simply a government railway—if China can be said to have a government. Before going into the question of proposed lines and railway schemes, I wish to say a word about the construction of the existing lines. They are all of standard gage; the rails, from Tientsin to Shan Hai Kwan, are of the Sandberg type, 65 lbs. per yard. From Tientsin to Peking they are Sandberg, 85 lbs. All of the new sleepers came from America; many of the old ones came from Vladyvostock and Japan. The embankment is somewhat wider than ours, and with a very wide berm. The bridges are all built of steel, and, with three exceptions, are riveted trusses. There is only one American bridge. The foundations are carried very deep by means of caissons, and the piers and abutments are of cut stone laid in Portland cement. On the new line to Peking nearly all the masonry is of Portland cement concrete, owing to the great expense of suitable stone. The entire line has at least one foot of broken stone ballast. No expense or careful engineering superintendency have been spared to make the railways thoroughly first-class in every respect, and the lines now built and in operation will compare most favorably with some of our very best roads in the states.

These railways have not been built exclusively upon either English or American designs, but with such combination and changes of both as best suited the requirements of the peculiar environment. The best of each system was adopted, modified and used. The rolling stock is built here, with the exception of the locomotives and handcars. The passenger cars are much below our standard, but still too good for the class of passengers carried. In a short time there will be special arrangements for foreign passengers. The locomotives are mostly from Glasgow. There is one American engine, made by the Grant Locomotive Co., that has been most unfortunate in the treatment it has received, but which still does most excellent work. All the locomotives for the Peking line are American, built by the Baldwin Locomotive Works. They are on the way now, and will arrive some time in July.

So much for existing railways. There is now under construction a line from Peking to Pao-ting fu, 80 miles. This is the first section of what will be the trunk line of China, Peking to Hankau, Hankau to Nanking, Canton, Hung Kang, etc. There is also under construction the Wu Sung line, 12 miles, from Wu Sung, at the mouth of the river, up to Shanghai. This is being built by the Germans, with a tremendous staff of engineers and much red tape. The country through which it runs is about as rough and mountainous as a first-class billiard table. The proposed lines that have been surveyed are as follows: The Peking-Hankau line, about 800 miles, and two feeders to this line running into Shanghai; one from Chung ting fu to Tai Yuen fu, the capital of the Province of Shansi, about 200 miles long; and a line from Su Chow Chien to Lu An fu, and south from there for about 30 miles into the iron and coal region of Si Ho Chien. Both of these lines run through a rich agricultural country, although parts of it are very mountainous, and they both tap an iron and coal region which, if properly worked, will make great changes in the world's markets of these products. These Shanshi lines will probably be started as soon as actual work commences on the trunk line.

We now come to the most important and all-powerful element in the politics of North China to-day. The Russians, through their diplomacy, are the ruling power. They do not beg for favor; they demand what they wish and get it. Through them the French are also much in favor, but they receive what favors the Russians choose. As you know by the papers, the Russians have been granted the right to construct a railway from some point on their Siberian line through Manchuria to Port Arthur, which they will use as a winter port. They have the right to have Russian troops at each station, with a large force at Murkden, and in case the Imperial Chinese Government is in any danger, they can occupy Peking for the protection of the Emperor. If they ever get in here you may be sure H. R. H. will be well protected. The Russians also have the right to enlist Manchurians as Russian soldiers. The Russian engineers are now engaged on the preliminary surveys of this line, and the work of construction will probably proceed rapidly.

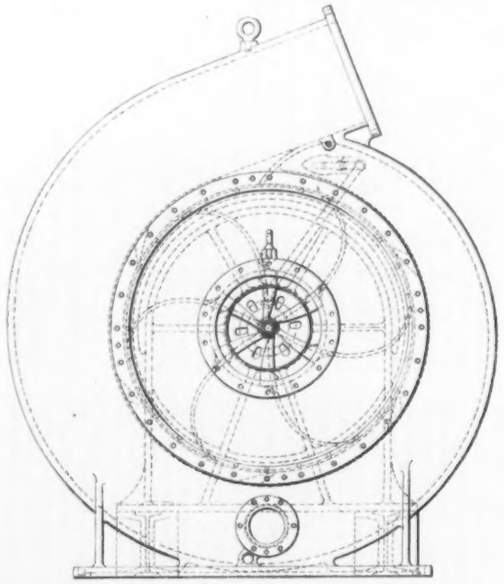
As to the Hankau line—the English, French, German and Americans have been fighting and scheming for this concession for the last two years. About fifteen months ago this line was put entirely into the hands of a high mandarin, Sheng Tao-tai (Tao-tai is a title), with orders to procure the necessary funds and proceed with the work. The Imperial Government was to give 10,000,000 taels (a tael is about 70 cts. in gold). Sheng said the Chinese would subscribe ten millions, and about twenty millions were to be borrowed from foreigners. A large English syndicate kept a man in Peking on this scheme for two years and got nothing. An American, Col. Jefferds, seemed to think it belonged to him, for some unknown reason, and when he did not get it did a great deal of injudicious writing in the English-Chinese papers, which, to say the least, has not improved the chances for Americans with the Chinese. The Bryce syndicate, represented by Col. Bash, worked long and hard in a most businesslike manner and at one time it seemed as if they would be successful, but nothing materialized, owing to a question of security.

The Director-General Sheng is not a reliable man to work with, from a standpoint of Western ethics. At last the concession was given to a so-called Belgian syndicate, and now the final details are being arranged. The Belgian syndicate is owned by the French, and the money is furnished by them and is guaranteed by the Russians. It is a triangle, of which Russia is the base. Just what turn affairs may take within the next month is unknown.

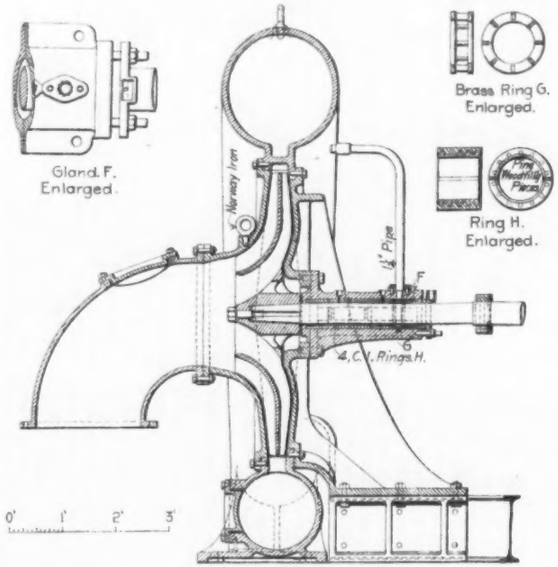
The general terms of the agreement are about as follows: The Chinese pay 4% for the money, of which they get only 90%; the syndicate get 5% on all material purchased, no matter where. The Chinese may operate the line for three years, and then, if not satisfactory, the syndicate may take it, principal and interest to be paid first, and then for twenty years the syndicate and the Chinese divide the profits. After that everything belongs to the Chinese. Long before that time the Russians may control all of China north of the Yangtze Ho. This is a statement of the railway situation in China as it is to-day. Now in regard to the so-called "Opportunities for American Engineers and Railway Builders."

On the lines already constructed, including the Poa-ting fu line, there are about 14 foreign engineers. Of these, with two or three exceptions, all are English. The chief engineer is English, and it naturally follows that the greater part of his assistants should be of the same nationality, without prejudice to other nations. On the Hankau line all of the engineers will be French or Belgians. In regard to the Shansi lines, it is undecided as yet what nationality will get them. Nine-tenths of the engineers come to China under contract for a number of years, and no engineer, of whatever nationality, has more than one chance in one hundred of procuring employment if he comes here without previous arrangement, or with money sufficient to be able to be idle a year and travel some. Even then his chance for employment is most uncertain. This applies with more force to American engineers than any others, for the reason that there are no large American business houses here. No American syndicates that have any business are here, and the policy of our government is such that neither our Consuls nor Ministers can render any aid to individuals or firms. The French, Germans and Russians, on the other hand, often simply compel the Chinese to employ one of their people at a fixed salary, whether they wish to or not. Mr. Van Bergen, in his letter, speaks of the great desire of the Chinese for Americans and American things. That is all nonsense; they don't care a rap for any nationality, excepting the French and Russians, and they love them as the small boy loves the schoolmaster who stands over him with a good birch rod. They want American machines, engines, cars, etc., when they cost less than any others; that is all. Mr. Van Bergen quotes the extension of time on the tenders for the cars for the Wu Sung line as an example. I will send you a blue print of those same cars in a few days; they have four wheels; are about 20 ft. long; will seat 28 people; have side doors, and are of a type that was antiquated, even on German railways, 20 years ago. The specifications were such that they practically could not be built outside of Germany or Belgium.

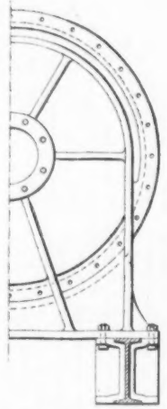
In regard to locomotives, all that have been tendered for the last year have gone to America, with the exception of four small ones to Belgium. Baldwins have the majority; Brookes and Rogers the others. But look at the prices in the last tenders opened in Shanghai, on May 1, for eight heavy Mogul locomotives, delivered in China. The price included not only the eight locomotives complete, but about £650 of spare parts. The English and



Front Elevation.



Vertical Section.



Part Rear Elevation.

FIG. 26. ORTON CENTRIFUGAL PUMP FOR SUNSET IRRIGATION DISTRICT.

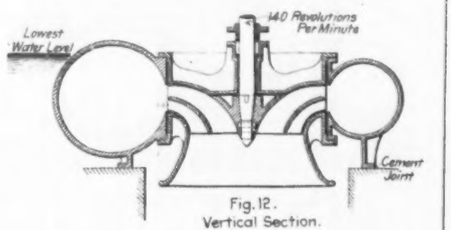


Fig.12.
Vertical Section.

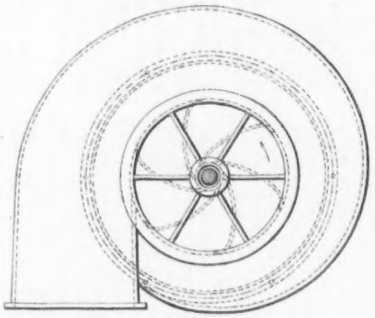


Fig.13. Plan.

FIGS. 12, 13. VERTICAL CENTRIFUGAL PUMP OF 70,000 GALLONS PER MINUTE CAPACITY. DESIGNED BY ALBERT FOWLER, LEEDS, ENGLAND, 1896.

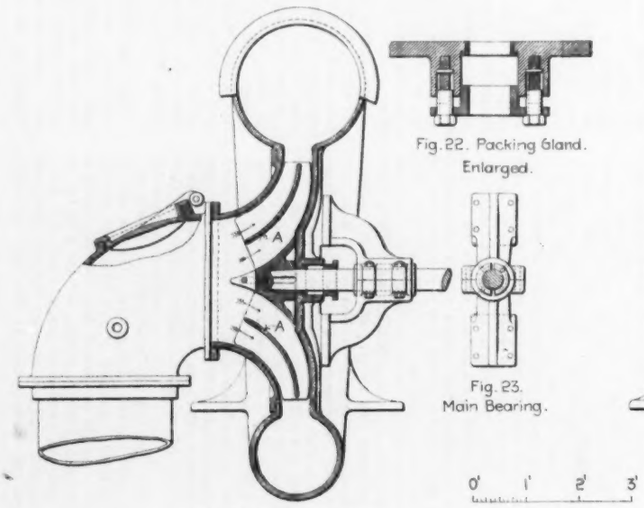


Fig.20. Vertical Section.

Fig.22. Packing Gland.
Enlarged.

Fig. 23.
Main Bearing.

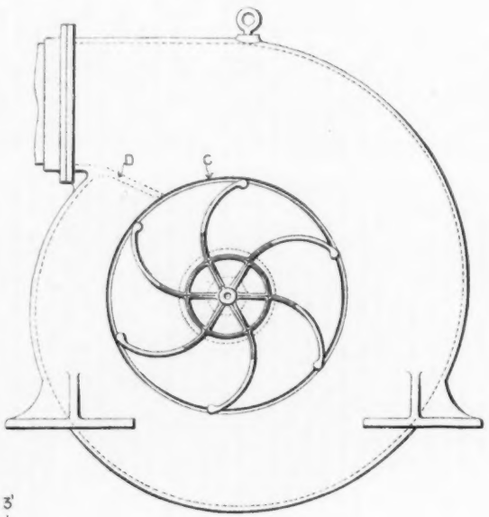


Fig. 21. Side Elevation.

FIGS. 20 TO 23. DRAINAGE PUMP FOR SACRAMENTO VALLEY, 40 CU. FT. PER SECOND.

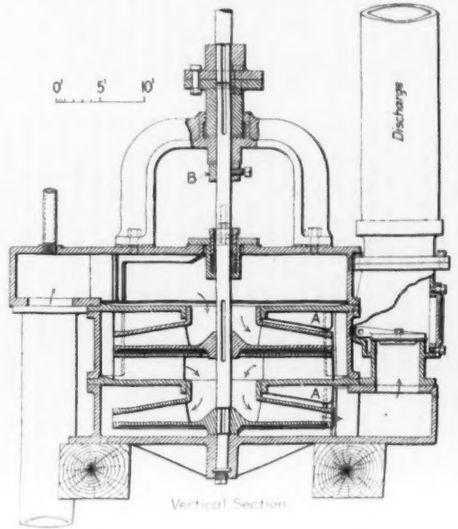


FIG. 25. COMPOUND PUMP FOR IRRIGATION, 1885.

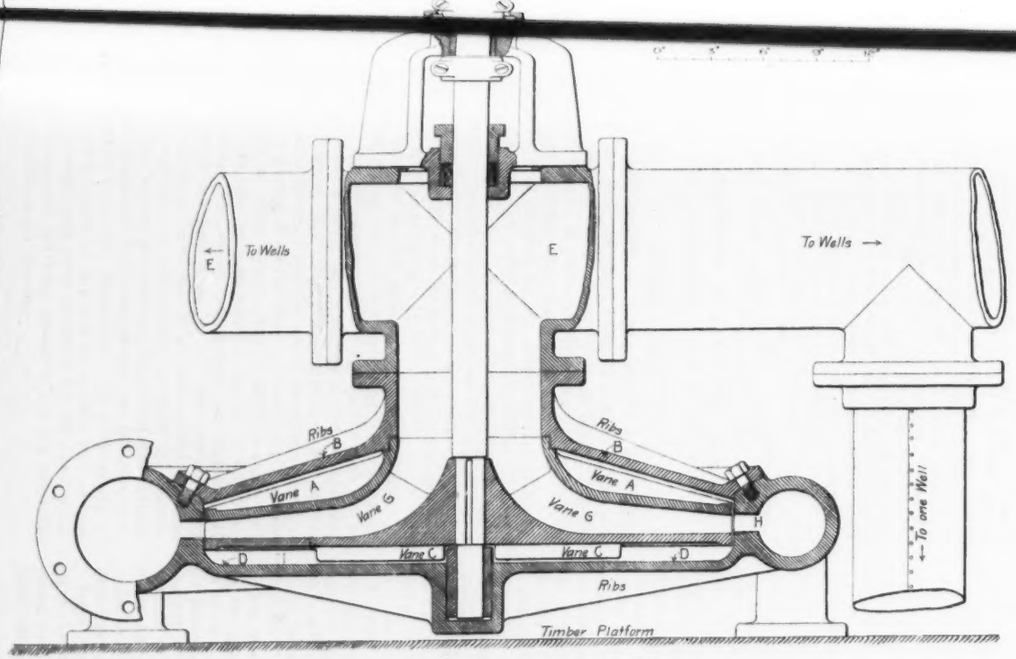


FIG. 24. PUMP FOR IRRIGATION WORK.

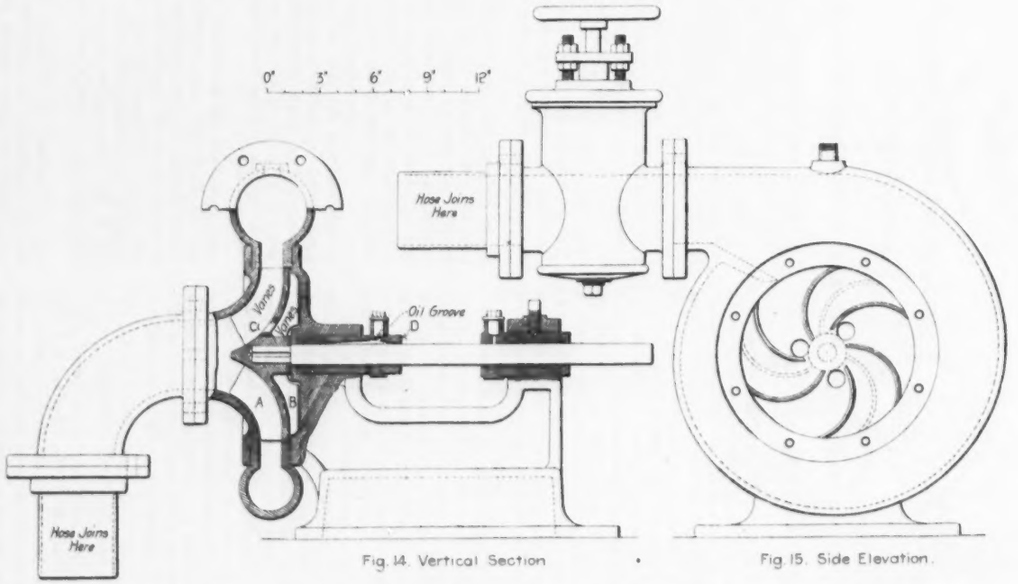


Fig. 14. Vertical Section

Fig. 15. Side Elevation.

FIGS. 14, 15. SMALL CENTRIFUGAL PUMPS TO BE DRIVEN BY ELECTRIC MOTORS, FEATHER RIVER DRAINAGE, 1888.

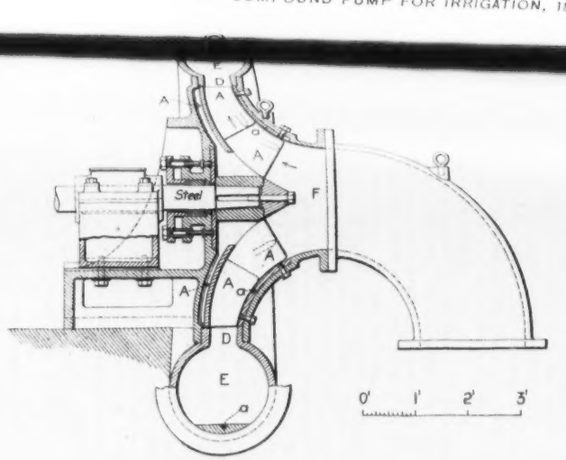


Fig. 19. Vertical Section.

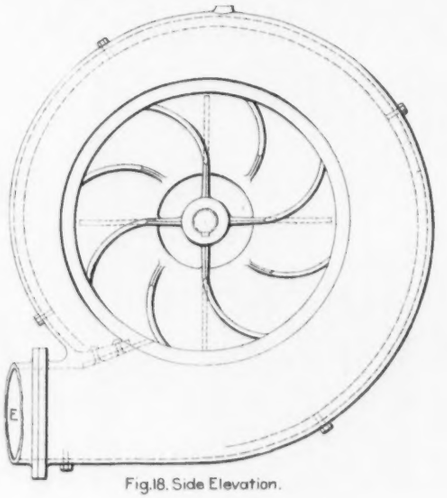


Fig. 18. Side Elevation.

FIGS. 18, 19. HIGH DUTY DREDGING PUMP, 20 CU. FT. PER SECOND CAPACITY.

THE DESIGN OF CENTRIFUGAL PUMPS.

(By J. Richards, San Francisco, Cal.)

CHAS. HART & SONS, LITH., 38 VESEY ST., N. Y.

German bids were from £37,000 sterling to £28,000 sterling; the American bid that secured the contract was £20,200 sterling. The Chinese do like American locomotives under such circumstances.

The above statement in regard to the locomotives is correct, but not exactly fair to the Chinese. Some of the more enlightened among them do believe in American railways and in American railway supplies, and would pay a fair price for them. The very low price at which these last locomotives went was due not to the Chinese, but to the idiotic cutting of each other's throats among the American representatives.

In regard to railway builders, as I understand the term to mean contractors for the construction of the roadbed, masonry, etc., no foreigner can compete with the Chinese. The masonry costs less than it does in the states; concrete very much less, as the best imported Portland cement is 30% cheaper here than in the states; and as for earthwork, here is an example: All of the earthwork for the Peking-Tientsin line was let to one Chinese mandarin, some 80 miles of it. It was all embankment, from 3 to 10 ft. high. The average price for the whole amount was 2 7-10 silver cents per cubic yard. Do any of our railway contractors wish to try to compete with that, with wages at from 8 to 12 silver cents per day or less, and an unlimited population to draw from? Labor-saving machines are at a discount; you don't wish to save labor, and machines are only used upon such work as makes them absolutely necessary. In conclusion: The railways of China already built are well and thoroughly built in every respect; the rolling stock is admirably adapted for the conditions of traffic; it is economical to run and to keep in repair; both passengers and freight rates are much below any regular rates in America; the train service and the management of the traffic department is fair, considering the people with whom the foreign chiefs have to work, and all of this is certainly improving. It is to be hoped that future lines built by French, Germans or Belgians will maintain the high standard of construction established by the Imperial Chinese Railways under English management.

China is no place for engineering students who have just graduated, and is no place for any engineer unless he comes out under a definite contract. There is a great field for an American house with plenty of money back of it for the import of railway material, mining material, American sleepers and lumber, American piece goods and many other American productions, and the export of Chinese raw material, cotton, wool, skins, furs, silk, straw braid, etc. But to compete with existing English and German firms, the house must have a large capital back of it, and must work very slowly at first.

I hope that you will appreciate the fact that I have tried to make clear the actual situation here. If any American syndicate should secure a concession in either railways or mines, then, and not until then, will there be an opening for American engineers; and even then the contracts should be made at home.

Andrei Kimta.

Peking, China, June 24, 1897.

THE DESIGN OF CENTRIFUGAL PUMPS.

By J. Richards, San Francisco, Cal.

(With two-page plate.)

(Continued from p. 77.)

Vertical Centrifugal Pump—155 cu. ft. per second.

The pump, shown in Figs. 12 and 13, is, with one exception—those at Khatatbeh, in Egypt, built by Mr. Farcot, of Paris—the largest centrifugal pump of the vertical type made to this time.

It was designed by Mr. Albert Fowler, of Leeds, England, of the well-known works of John Fowler & Co., in that city, during the past year. It was changed from the first plans, which were for a double inlet, to the design shown, on lines laid down by the writer, and is a fine example of modern practice.

It is to operate against a pressure of about 9 lbs. per sq. in., and is arranged on what is known in this country as the Orton system, which will be discussed later. At a moderate flow through the discharge way this pump will pass 70,000 gallons per minute and have as much capacity as five piston pumps of 50 ins. bore, and will not cost one-fifth as much, besides lending itself in every way to the conditions of working; that is, it will pump sewage and safely pass solids not exceeding 12 ins. in one dimension. It will also safely destroy or break up by impact or abrasive action any kind of solid matter that is likely to enter the suction.

The curves, sections and other features indicate a design carefully worked out and the efficiency, which is not yet determined, will no doubt be as high as could be attained by positive pumps such as would have been available for the same work. The spindle is 7.5 ins. diameter and the speed 140 revolutions per minute.

There is one problem connected with this design that deserves attention, the bell-mouth inlet at the bottom, which as shown conforms as nearly as possible to the rules governing orifices for inflow; but there is the contingency of revolution of the water below the impeller and setting up a resistance by reason of the conoidal form and tapering sides.

There is not at this time any knowledge of how far rotation of the water extends back into inlet ways and there is much difficulty in ascertaining the form and degree of such rotation, the probability being, however, that the mass set in revolution beyond the impeller assumes a conical form, reverse to that of the inlet way, in which case an inward tapering inlet would not offer resistance.

As the present design is especially susceptible of resistance from this cause (rotation in the inlet way) the result obtained in its working may afford some useful data.

Special Throttling Pumps, 500 gallons per minute.

Figs. 14 and 15 illustrate some special pumps made in 1887 for draining the "pockets" or pits in the Feather River, California, in the section cut off by the celebrated diverting tunnel, constructed by Dr. Pierce, of Buffalo, N. Y., in 1888.

It was known that auriferous deposits of great richness existed in the alluvial bed beneath the Feather River at its original delta, or where it now leaves the foot hills and enters the Sacramento Valley Plain, a fact disclosed by all excavations made there, and it was assumed that similar deposits would be found in the present river bed, back in the mountains.

The scheme was to divert the river for some miles by means of a tunnel, and explore its bed, pumping out the pools and excavations made by the water, with small centrifugal pumps driven by electric motors.

The rate of rotation for motors as then made was very great, and as the pumps were portable they required to be as light as possible. These conditions demanded impellers of the least possible diameter, which, as seen, were made 10 ins. for pumps of 4-in. bore; not out of proportion for pumps of large size, but much less than is common for pumps of such small size.

Another condition was that the suction-pipes or hose should be free from all fittings or obstructions and the pumps should raise water at the rate of 50 to 500 gallons per minute, so the pits or pools could be cleared and then drained as the work went on.

This was done by throttling the discharge pipe, as the drawings indicate, and the result, so far as known, was satisfactory, but the scheme failed for reasons that would occupy too much space to explain here. They were all comprehended in the remark of an old miner, who said: "The Feather River has a new bottom every year, and if the rocks were all gilded they would be scraped clean in one season."

Some experiments made at the works to determine the effect of throttling the discharge showed great loss of power, energy being developed into heat and imparted to the water.

The experiments made were not with any view to ascertain losses, consequently there were no observations to determine the amount of heat passing into the water, but it was evidently in proportion to the losses beyond the normal resistances in pumping at full capacity.

In the case of some pumps for wine, made about the same time and arranged for throttling, the heat generated rendered the method impracticable. The gases given off by the fermenting wine soon filled the pumps so as to stop their working.

If a pump discharge way is closed there is, of course, a falling off in the amount of power consumed. The vacuum or suction head is in effect eliminated, also the friction of discharge flow, and the resistance is reduced to internal water friction and consequent development of heat, a well-known fact in physics, which is especially obvious in the case of a marine propeller driven in a fixed quantity of fluid and without progress into undisturbed water.

In fact, the analogies between a propeller screw and a centrifugal pump impeller hold good in various features of their action, as will some time appear when such pumps have received some share of the extended study devoted to marine propellers.

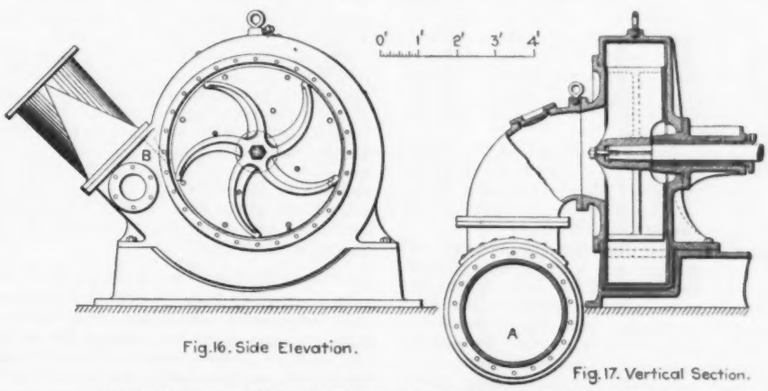


Fig. 16. Side Elevation.

Fig. 17. Vertical Section.

FIGS. 16 AND 17.—LOW DUTY DREDGING PUMP FOR BOSTON HARBOR, 1891.

It will be noticed that, as in the case of the pump shown in Figs. 1 and 2, there are vanes on each side of the disc, A and B. The front one, A, performs all the useful work, that is, the whole of the water passes outward on the front of the disc, the vanes, B, acting only to balance the propeller. In this manner centrifugal action is set up on the back as well as the front of the disc, nearly equal in each; but as the vanes, B, are a little shorter, as seen in Fig. 14, and the pressure correspondingly less behind the disc, there is a slow flow of water over the edge of the disc and through the holes C, which are provided to prevent the accumulation of air around the center.

This is a very complete manner of balancing a disk-impeller, which, however, has its principal importance in the fact that the amount of lateral thrust can be controlled at pleasure. In the case of vertical pumps it permits the weight of the rotating parts, the shaft impeller, etc., to be sustained by the water pressure.

This method of balancing was adopted in the Faesch & Picard water wheels at Niagara, and a good deal was said about it in the technical press, but it was well understood in hydraulic practice even before the issue of Bulletin No. 2 by the University of California, in 1887.

One other feature of the present pump may be mentioned; the arrangement of the main bearing to form a packing gland, the sleeve, D, performing both of these functions. This shortens the spindle and framing and is a neat design in every way.

Low Duty Dredging Pump of 25 cu. ft. per Second Capacity—36 cu. ft. per second.

The pump shown in Figs. 16 and 17, was designed in 1891 for use in Boston Harbor, and was the third of the same type made with special reference to dealing with solid obstructions such as are invariably met with in harbor work. The pumps were intended to work against a low friction head

or with short discharge pipes and the name "low duty" is applied because of the low centrifugal force in proportion to the power consumed.

The operation of dredging, while seemingly of nearly uniform character, is in fact one that calls for the widest variation of design, so much so that the pumps, as future examples will show, require totally different construction for different cases.

When the first pump of the present type was designed by the writer in 1888, an examination of the "log" in one of the marine dredges disclosed the fact that the main item in the expense account was charges for detention by breaking down of the pumping apparatus and intake machinery.

If a break-down occurred here, the crew were idle till it was repaired, and the whole of the wages, as well as the cost of replacement or repairs had to be charged to the expense account, so that the design of a pump for the work had to be based on this fact and efficiency had to be sacrificed to other conditions.

The solids that come up with the silt in harbor dredging are a matter of amazement to those without experience. Screw bolts, stones, sections of chains, parts of stoves, water-logged timber, with all other things conceivable, must be dealt with. Screens are impracticable because they soon clog, common catch-boxes cause a considerable loss of power and the only safe way is to construct the pump in a manner that does not permit injury and so that it will disintegrate and pass everything through that is not too large for the ducts and passages.

The most difficult work is around wharves where iron scrap is unloaded from vessels, a portion always falling overboard, but in all cases harbor spoil is filled with solids of various kinds thrown in from the wharves or from vessels.

Encased impellers with tapering passages are wholly unsuitable for such work because of clogging, and also because obstructions are not broken up or worn out as in the case of open vanes.

Provision to guard against such accidents can be traced in the pump shown in Figs. 16 and 17. Anything that will pass the inlet will find its way through and out of the pump. Heavy pieces lodge or stop at the bottom of the pump and are not carried around by the vanes.

A catch-box, A, is provided, but is not, as shown in the drawing, of a commendable form. The casing, being of angular section, does not permit a wedging action when solids are driven out against the periphery. The impeller and other interior parts are strong enough to stop instantly by obstruction without breaking.

The throat-piece at B, Fig. 16, is either omitted or arranged so it can be carried away without injury to other parts. The best way is to omit it altogether, but the "Parsons' experiments," that for a period of twenty years were considered a guide as to the value of these baffling throat-pieces made it expedient to employ them in deference to common opinion, even for dredging pumps.

There is besides the friction of solids due to a wedging action, the adherence and friction of viscous material on the interior of the casing or volute. Such material discharged into a curved or converging channel causes a great deal of resistance, which is avoided by the rectangular section, a characteristic of the present design and one worth attention when tenacious silt such as the "slickens" in San Francisco Bay is to be dealt with.

All these features and others affecting harbor dredging are factors opposing efficiency, and a compromise has to be made between the loss of power and losses of other kinds. The problem of design is affected also by the distance to which the spoil must be forced, or, as it is called, the "friction head;" also the varied character of the work, because a dredging pump is liable to be employed in handling various kinds of material.

It is evident, therefore, that a designer of such pumps has before him an array of uncertain conditions. By satisfying one, he traverses another and lays his work open to criticism if judged from fixed premises of any kind.

In the present design, for example, it will be noticed that the vanes of the impeller in Fig. 16 are curved backward so that their tips are at a tangent of 30°, which is wrong for a low friction head when discharging into barges or through short pipes. But the owners expressed an opinion that the pump might sometimes be employed to work through long lines of pipe, and the vanes were made so as to avoid dragging resistance. For low resistance, vanes should be radial or even curved forward.

The discharge way is arranged so that the pump will remain nearly full of water, will start without charging and will not require a gate or valve in the discharge pipe.

In the first pump of the kind made there was a detachable throat-piece provided at B, a plate of steel half an inch thick, held by bolts that could be inserted and screwed up through a man-hole at the side. The attendants were requested to observe the effect if this plate was carried away, a thing easy to do because there was provided a gravity stand-pipe on the discharge-way so that the friction head could be observed at all times. The plate went out in a short time and the men reported that the speed of the pump and the friction head remained just the same.

The vanes of the impeller, it will be observed, are not supported by a web between them. This is necessary because such a web would obstruct the flow and prevent flexure of the vanes when they strike any kind of solid drawn into the pump or in case of obstruction at the throat.

The material enters at a right angle to the plane of rotation and is not, as will be shown in the next design, set in revolution before reaching the impeller, a provision impossible in the present pump because of the relative diameter of the inlet-way and the impeller and other proportions which were necessary to secure a certain speed of rotation adapted to the engine and gearing. For harbor work the impellers were of steel, in other cases of cast-iron. The pump was designed to consume a maximum of 400-HP.

High Duty Dredging Pumps—20 cu. ft. per second.

By contrasting Figs. 18 and 19 with the pump last described, it will be seen that there is but little analogy and the differences are so great that the pumps seem to belong to different classes of machinery. In the present case everything, so far as possible, has been done to increase centrifugal effect, or to produce pressure, with a view of driving silt and sand a mile or more through the delivery pipes.

The efficiency, while high for a dredging pump, is impaired by the change of velocity at D, where the flow is reduced to one-half that at E and F, the passage being enlarged that much to avoid obstructions by clogging, and there is also the resistance of rough surfaces on the lining plates a and on the back plate. These things reduce the efficiency about 10% below a water pump of the best class.

The internal friction of a centrifugal pump is what may be called a "constant quantity." We sometimes hear of encased, or hollow, impellers, to avoid friction on the sides of the casing, but it is obvious that the plane swept by the impeller must present a constant area of frictional surface.

If the impeller is encased, the water friction is on its outer surface and if open it is on the side plates of the casing; but wherever it exists, the surfaces should be turned true and smooth if a high efficiency is aimed at.

In the present pump there is a seeming danger of breaking the front or working vanes A, by their striking stones or other solids, and there would be such danger if it were not for the form of the inlet, which is such that the water and material is in full revolution before the vanes are reached, and this is a circumstance that has to do with a common impression that the vanes must "scoop up the water," as a recent writer on the subject describes it.*

The water in a pump must be considered as a solid and is not "scooped" up or otherwise acted upon as if free and mobile. These ideas of inertia, re-entering curves of the vanes, a propeller form at the inlet, and so on, are all based upon conditions that do not exist, and such contrivances usually produce retardation, especially in pumps designed to operate at high velocity.

In common centrifugal pumps at average heads the water requires to be set in revolution by the most simple means possible, and does not approach the impeller without rotary movement to be "scooped" off by the forward curved vanes or propeller blades; but it is, or should be, in revolution when it reaches the impeller, at a velocity very little less.

In Figs. 16 and 17 this is not the case, for reasons that have been explained, but in the present pump there will be no fracture of the vanes unless by wedging action against the front lining, a thing not likely to happen.

The pump is unbalanced to the extent of 30 sq. ins. area, which, with a friction head of 30 ft., will amount to about 400 lbs., or enough to keep the spindle in a state of rest longitudinally and prevent side motion of the impeller.

There will no doubt be a query as to why the curved front lining A is not made integral with the vanes A, so as to revolve with them. This would seem a proper and simple construction, but there is good reason for not adopting it. If this front lining were a running plate, the pump would clog with whatever might lodge in the tapering passage, but one surface being fixed, the rubbing action will abrade and wear away anything but metal that lodges in the pump. Even stones will soon be ground away so as to pass out at the throat. This explains a principal objection to encased or enclosed impellers for dredging pumps. Such impellers have tapering passages to invite clogging and have no means to disintegrate or wear away lodged material.

The disintegrating devices, intake contrivances, and pipe-line connections have passed through much modification in this country, and while not made with the care and expense that European dredging apparatus has been, the results attained have been quite successful. These things, however, lie outside of our present subject.

Centrifugal Pump Drainage.

40 cu. ft. per second.

The pump shown in Figs. 20 and 21 is one recently constructed for a drainage district in the Sacramento Valley, near the city of Sacramento, Cal., by the Fulton Engineering & Ship Building Co., of San Francisco. The design was prepared under the Orton patent, and the tests, which are soon to be made, will no doubt show as high an efficiency as is attainable for pumps of this class, or for draining purposes.

The construction varies in several respects from common practice. The back plate is integral with the casing, and the front plate is removable to insert the shaft and impeller, both of which can be removed in a few minutes. The water passes on each side of the continuous curved web A, in two bodies slightly different in volume, the curves being easy or of longer radii than is possible with a double or forked inlet.

The pump requires no base frame, having only flanges that are attached to channel bars of wrought-iron imbedded in concrete, and as the pump is at the side and outside of the foundation. the latter is simple and inexpensive. This method of securing foundation, stability by buried or imbedded bars of wrought-iron is a comparatively new feature, which, as in the present case, dispenses with ponderous cast-iron framing and secures a firmer attachment of the superstructure than is possible by means of the usual bolting down of base flanges on masonry. The packing gland, Fig. 22, and the main bearing, Fig. 23, present some points of novelty in pump design, especially in the saving of material and in gaining accessibility and compactness. The head to be operated against is a maximum of 20 ft. and the vanes as seen in Fig. 21, are curved so as to be suitable to a velocity ratio of the impeller of 5 to 1 as compared with that of the water that surrounds it, or at the "parting," so to call it, on the line C, Fig. 21. In this feature arises a problem that has consumed a great deal of time in computation without any corresponding result. This problem can be explained by supposing the cut-off plate D removed so that the rotation of the water discharged from the impeller will gradually and in a volute path, fall from 40 ft. to 8 ft. per second, or supposedly so, because no one has proved that any such action takes place without an annular diverging chamber beyond the impeller.

Opposed to this is the proposition carried out in

*Bulletin No. 9, California State Mining Bureau, 1896.

the present design, that the angle of discharge is at a head of 20 ft., approximately, in the plane of the plate, or vane D, and that the inductive action of the water discharge from the impeller, acting on the slower moving body in the casing or discharge way, is of more importance than the rotative energy gained by a gradual change of velocity.

If the parting line, C, is expanded into a tapering chamber of some width between the impeller and the volute discharge-way, as proposed by M. Schabaver, then some gain in dynamic effect or efficiency is obvious; but this construction is at the same time subject to limitations that outweigh the gain unless for some special service.

The cost of a centrifugal pump is approximately as the square of its extreme diameter, over the casing, and a maker that would add the dimensions required to carry out the theory of a diverging annular chamber to permit a gradual change of rotative velocity, would find his competitors making the pumps to be contracted for. This, it may be remarked, is an element in design that leads to divergent methods of construction—the difference between theory and expediency.

For example, suppose that the present pump shown in Figs. 20-21 had been arranged with a forked and double suction pipe and an encased impeller. The acute wedge that is necessary to divide the flow into two parts in the suction pipe would tend to cause obstruction by tule roots, bean straw, or other vegetable debris that would become balanced across the wedge. The pump shaft passing across and obstructing the water at the pump inlet ways would "wind" the same kind of debris and clog on one side at a time, and this, if not discovered, would soon destroy a pump by lateral thrust on the impeller.

An encased or enclosed impeller would soon clog by debris such as is always present in draining tule and cultivated lands, and when clogged would remain so, while an open impeller, like the one shown, soon wears out by abrasion any solid that will not pass freely through the pump.

Thus it will be seen that complete rules for the dimensions of centrifugal drainage pumps should include a factor for "tule roots" and "bean straw;" also one for stones and scrap iron in the case of dredging pumps. But jokes aside, it is easy to perceive that a machine or implement that demands modification for every considerable change of the intensity of its work and for different kinds of material to be operated upon, is not likely to become amenable to "specific" rules within a period of less than 40 years, since centrifugal pumping began. Piston or reciprocating pumps are some centuries old, and as before remarked, are adapted to a wide range of pressure without change of design, yet these are far from perfect. The problem of continuous flow in such pumps for one thing is a very important one, just now in course of evolution. The construction of valves and the manner of their operating are also subjects of recent discovery and change.

Centrifugal Well Pumps—800 Gallons per minute.

Figure 24 shows a pit or well pump such as are employed on the Pacific Coast for raising water from gravel strata for irrigation purposes, and is one of the most interesting among the various modifications in modern centrifugal pump practice.

The alluvial plains, and these include all arable plains in California, are nearly everywhere underlaid with gravel strata of varying thickness and at various depths. These gravel strata form both the storing space and the "conduits" of flow for subterranean water, the interstices in average gravel permitting saturation to the extent of 30 to 40% of the volume as the gravel is fine or coarse.

The slope of these gravel veins correspond to that of the streams which deposited the gravel, and is comparatively flat, so the flow of water in the strata is very slow, rarely exceeding 7 ft. an hour in coarse gravel, and half as much in fine or mixed gravel, or on an average of 84 ft. a day, or about six miles a year.

Skilled engineers who have in various parts of the country explored underground water supplies can, from the general topography of the country around and various other signs, and especially by boring, predict with tolerable certainty the amount of water that can be drawn from wells and also the permanence of the supply.

Until the advent of centrifugal pumping, about 16 years ago, this water, while so near the surface, was scarcely available, because any pump having pistons or valves could operate but a short time by reason of the scour from the fine gravel and sand held in suspension or washed into the sumps or wells.

Whenever the water is drawn down at one place, the effect is to increase the flow to that point corresponding to an increase of slope and all the fine material that has lain for centuries in a current of three to seven feet an hour,* is subjected to a current ten times as rapid and the result is that in all these gravel wells a quantity of fine gravel continually comes up with the water.

A pump drawing 1,000 gallons per minute will deposit sometimes 10 lbs. an hour at the outfall, of fine gravel and sand, which as a matter of course would soon destroy all surfaces exposed to rubbing action. Sometimes pump leathers would be destroyed in a few hours, this being the best kind of material that could be employed.

Centrifugal pumps changed all this. They have no valves, no sliding contacts, and gravel had no effect on them; but many years of experiment and evolution were required to secure an adaptation that would not cause delay by break-downs and other causes due to the high speed and the difficulties of transmitting power down into the pits 60 to 90 ft. deep, common in the pumping districts.

The method is to sink oblong pits about 4 ft. wide and from 8 to 16 ft. long, down through the clay or gravel strata as far as possible in the dry season; that is, sink until the inflowing water exceeds the means for its removal, or until there is assurance of a sufficient supply. The water thus developed is only in part depended on for supply; that comes mainly from tube wells sunk in the bottom of the pits, from one to four in number, 100 to 200 ft. deep, and reaching down until a sufficient thickness of gravel is passed through, seldom less than 10 ft. in thickness, which may be in several strata of unequal depth.

Certain distinguishing features of such pumps are (1) they are driven by vertical shafts running from 400 to 800 revs. per minute. (2) They are mounted on movable platforms that can be raised or lowered as the water level changes. (3) The rotary parts, that is, the shaft and its fittings, with the pump spindle and impeller, are supported and held in equilibrium by water thrust. (4) The suction pipes have no valves and extend down into the tube wells about 40 ft. (5) The uptake or discharge pipes are made about four times the area of the pump discharge and are fitted with strong check valves and air vessels of large size. (6) The tendency of the whirling water to remain in one plane, or its "kinetic stability," offers a considerable resistance, and is avoided as much as possible by a long curve in the discharge pipe at the pump, where the course is changed 90°.

These various features of a modern pumping plant offered material for extended discussion that can not be included in the scope of these articles, further than is afforded by the drawings of the pumps themselves, which will now be referred to.

Fig. 24 represents one modification of the high-lifting class of pit pumps, of which a large number are now in operation. These pumps are varied a good deal, but a single example will embrace most of the features of interest. Difference in design relates chiefly to methods of balancing the water thrust. The bearings of the pump spindle are short, and not compensating. They are nearly devoid of lateral strain and do not require much surface.

The ample collars above and below the top bearing are required in starting the pump, before it fills and until the water pressure sustains the weight of the shaft.

The impeller is in this case of the enclosed type, but is provided with vanes A on the top, also with shorter vanes on the bottom. The interior of the pump cover B is turned true, so also is the bottom plate D. If these surfaces were not turned true the pump would be nearly inoperative, because the stratum of water between the impeller and these faces, being practically a solid, and in revolution, can not adapt itself to inequalities of section, and the tendency is to spring the impeller at each revolution to the extent of any inequalities on the faces of the pump covers or side plates. This, which seems a simple matter when explained, but in one case within the writer's knowledge several impellers of the disk type were broken before the cause was discovered. Like many other things in centrifugal pumping, this was not foreseen but learned by experience.

It will be obvious that an encased impeller like the one shown cannot fit around its periphery so as to prevent flow into the chambers below and above, or at its sides. Supposing the vanes A and C were omitted and the impeller were turned true on the outside, and there were no rotation of water outside of the impeller, then the whole interior of the pump would be subjected to a pressure equal to the head, and supposing the area of the sides or top and bottom of the pump to equal 1,000 sq. ins., when the impeller is 30 ins. diameter, the pressure at a head of 60 ft., to be about 25 lbs. per sq. in., or equal to 25,000 lbs. This seems enormous, but any weakness in the castings will show at once the existence of such a force. It may be claimed that this pressure is reduced by the inductive action of the discharge at H, and it is, no doubt, to some extent, not known or computable, but it must also be considered that the flow there is much reduced because of the enlargement of the water passage, which cannot be less than 1 in. in width, to prevent lodgment of large gravel, which would put the impeller out of balance and otherwise disturb its action.

Assuming that the rotary parts consisting of the shaft and all that is attached to it will weigh 2,000 lbs. (which is near the actual weight for the pump shown in Fig. 24), it will require an area of 80 sq. ins. to balance this weight. The impeller, 30 ins. diameter, if fully exposed to this pressure would sustain a force of 17,660 lbs. on each side, but the inlet way, E, being 8 ins. diameter, relieves that much area. Deducting the spindle leaves an area of 46 sq. ins. free from the internal pressure, causing an upthrust of 1,150 lbs., but leaving 850 lbs. additional to be provided for in the action of the impeller or the water around it. There are several methods of doing this, all of which are directed to modifying the centrifugal action on the upper and lower sides of the impeller.

Referring to Fig. 24 as one example, and perhaps the easiest to explain, the impeller is provided with the vanes A on top, of the same length as the vanes G within it. Centrifugal force may, therefore, be assumed the same within and above the impeller and the extra 850 lbs. required to balance the shaft and its accessories must be gained from action on the bottom of the impeller. This is accomplished by making the vanes C shorter in length to some extent, not very easy to determine and usually arrived at by an experiment or two. Sometimes a balance or equilibrium is attained by placing weights on the top of the shaft, a method that permits adjustment in case of the water sinking in the wells, which is a very common occurrence and is the reason for providing suction pipes that exceed in length the atmospheric head.

The ample collars at the upper spindle bearing are also to provide for a change of head, the top collar being especially arranged to sustain downward the thrust at starting and until the hydraulic pressure begins.

In the writer's latest practice the encased impeller has been discarded for a disk with vanes at each side, or for the Orton patent impeller shown in Figs. 21 and 22.

In fact the use of encased impellers is questionable in nearly all cases, and it is probable that they will in time disappear here as they have in Europe with the best engineers and makers. One objection to the system, an insuperable one, is the waste of water through the running joints at the inlets, which, if escaping at the full pressure of the head, amounts to a large share of the whole after this joint has become worn.

*The rate of flow is taken from the tables of Mr. George Manuel, Civil and Hydraulic Engineer, of Fresno, Cal., whose experience in underground water supply has been varied and extensive.

Compound Pit Pump.
600 gallons per minute, 90 feet head.

The example shown in Fig. 25 was made in 1885 to raise water for irrigating purposes near San Jose, Cal., and was a third or fourth one made on the compound method. It is also one of a larger number constructed on the plan of those invented by Sir Henry Bessemer about 1850, in which the tangential energy of the water was not considered, the casing being circular and the water duct around the impellers an annular chamber.

The present pump was mounted on a fixed platform about 80 feet below the surface, and the season being a dry one the water rose and covered the pump, which was not seen or touched for a period of four years, but was always ready for duty when required. It is a pump of low efficiency, owing to the tortuous water ways, especially when driven to its full capacity, but it was a typical link in the process of evolution. It is also inferior to later modifications of compound pumps and is not presented as an example of good practice, but as a matter of history.

The whole head pumped against was 90 ft., equal to a pressure of 39 lbs. per sq. in. in the bottom pump and half as much in the top pump; and the upthrust on the impellers about 5,000 lbs. if there had been no revolution of water outside the impellers. There were, however, but two baffling vanes A, and some centrifugal effect, so that the upthrust was about 4,500 lbs., 2,500 lbs. of which was counteracted by the shaft and its fittings, leaving 1,000 lbs. to fall on the collar B and other collars above. This was a bad feature and caused the only difficulty in operating. It was successfully combated, however, by the pump being submerged above the collar B.

The method of compounding centrifugal pumps, or working them in series, is a subject permitting and deserving a good deal of discussion, but it is less disparaging than true to say that we had better first learn to make single pumps and then proceed to compound or multiple designs. The history and facts of the compounding system are against it, also the economic results, considered in respect to both first cost and maintenance.

A compound pump is an inaccessible kind of machine and has concealed joints and parts that cause anxiety, especially at high speed. The speed of the present pump was from 850 to 900 revs. per minute.

Special Centrifugal Pumps, Orton System.
33 cu. ft. per second.

The pump, shown in Fig. 26, is illustrated in detail, except the supporting framing and the development of the impeller, but is not presented as one of high efficiency or of normal proportions in all respects.

The design was prepared in 1894 for the Sunset Irrigation District in Southern California, for a head of 20 ft., but had to be adapted to a particular speed of revolution to suit certain water wheels to which the pumps were to be directly connected. This produced distortion of various elements, the diameter of the impeller for one, but the example is none the less interesting because of this fact.

It may be also mentioned that since that time there have been various improvements in constructive details, as some previous examples will show, also, that the present pumps were arranged for "compounding" so as to deliver water at 40 ft., as well as at 20-ft. head, passing it through two pumps for the higher duty. The total volume to be raised in this case was 300,000 gallons, or 40,000 cu. ft. per minute, requiring ten pairs or twenty pumps in all.

Litigation and various contested features have prevented the enterprise from proceeding for three years past, but recent Court decisions on what is known as the "Wright Law," will, no doubt, permit the work to go on.

These articles, while not assuming the importance of an essay, or carried further than the observable and elementary features of the centrifugal method of raising and impelling water, will serve to show the many and complex problems that arise in the design of such pumps; and also will show the fallacy of assuming that a particular form of centrifugal pumps can be an invention or discovery of general application.

There have been discoveries or inventions that apply to "classes" of pumps. The balancing of the impeller in respect to lateral thrust is among such inventions, but it is not applicable to double inlet pumps which form a numerous and important class for low heads and large volumes of clear water, and when high rotative speed is desired, as in the case of direct connection to steam engines, electric motors and turbine water wheels.

In the majority of cases double or forked inlet pipes are adopted because the makers are not acquainted with methods of balancing when the water is introduced at one side.

The present example, Fig. 26, is seen to be equivalent to a double inlet pump, the impeller not being subject to the internal pressures that have been discussed, yet there is but one suction pipe, and the curves are easier than can be attained with an inlet at each side. It is, in fact, a double inlet pump, free from the objections that apply to the forked or double suction pipes. The objections to double inlets are: (1) the deviations of course are greater and the curves more abrupt; (2) the pump spindle is placed across the suction pipes, offering resistence and interrupting the flow; (3) the pump spindle, because of its great length between bearings, has to be made of large diameter and requires extra width of the structure, as a whole, at least 50% more room laterally; (4) the pump is less accessible, commonly requires a split casing and the pumps have in most cases to be set over instead of at the side of the sump or pit, from which the water is drawn; (5) the suction pipes, unless double for their whole length, are liable to clog. The passages also being half as large, endanger clogging by winding roots and like debris encountered in draining operations; (6) the cost of construction is greater by at least 25% for a given duty.

These seem a formidable array of objections, but they are by no means final as to design, because, as before remarked, there are countervailing reasons for adopting double suction pipes in many cases.

TEST OF A HIGH SPEED PUMPING ENGINE WITH A NEW SYSTEM OF WATER VALVES.

We are indebted to Mr. John C. Trautwine, Jr., Chief of the Bureau of Water of the Philadelphia Department of Public Works, for a copy of the report of two tests recently made by Prof. H. W. Spangler, M. Am. Soc. M. E., of the University of Pennsylvania, and Mr. Edward T. Child, on a pumping engine built by the Southwark Foundry & Machine Co., and erected at the Lardner's Point pumping station, of the Philadelphia Water-Works. The test is a remarkable one in showing that a pump built for a capacity of 15,000,000 gallons, and a piston speed of 180 ft. per minute, can be converted into a pump of 50% greater capacity, with corresponding increase of speed, by simply changing the water valves from the ordinary rubber-seated valves, moved automatically by the pressure of the water, to gridiron slide valves moved by small actuating cylinders using water from the force main. This increase in capacity was accomplished, moreover, without any increase, and, in fact, with a slight decrease, in the steam consumed per horse-power, and without undue heating or vibration. The following is an abstract of the testing engineers' report upon the tests made:

The engine is of the vertical compound crank and flywheel type, with double-acting plungers externally packed. The specifications called for an engine "so proportioned as to be capable of delivering not less than 15,000,000 gallons of water in 24 hours into a reservoir through a rising main 30 ins. in diameter and about 22,000 ft. in length. The height of the reservoirs, above the ordinary level of the forebay, is such as to give a static head of 185 ft." The pump valves were to be of hard rubber with vertical lift, the water-piston speed was not to exceed 180 ft. per minute, and the number of revolutions per minute were not to exceed 25.

In a letter to the Director of Public Works, dated July 13, 1892, the contractor asked leave to substitute sliding metal valves for the rubber valves specified, offering, if allowed to make such a change, to guarantee a capacity of not less than 22,000,000 gallons per 24 hours, providing the city would furnish a force main of a size to convey properly this amount of water. The Director of Public Works accepted this offer in a letter dated July 20, 1892.

The pump was accordingly constructed with water valves of the gridiron type, actuated by cams driven by eccentrics on the main shaft. It ran for some time arranged in this manner, but was subject to constant breakdowns. These cams were afterward removed and for them were substituted small actuating cylinders, using water from the force main. These actuating cylinders do not exert enough power to move the valve until the pressure on it has become balanced. At that instant, when the ordinary rubber valves would begin to move, these slide valves are lifted from their seats by a small amount; and there being then no friction to prevent their sliding they are swiftly opened by the actuating cylinders. This valve gear worked with entire smoothness and precision during both tests. On the recommendation of the Bureau of Water, the horizontal air pump was changed to a vertical one.

The specifications called for the following specific method of procedure: The engines were required to perform a duty of not less than 110,000,000 foot pounds, with 100 lbs. of steam pressure at the boilers. The duty was to be computed by the following formula:

$$\text{Duty} = \frac{\text{Foot pounds of work done} \times 1{,}000{,}000.}{\text{Total number of heat units consumed.}}$$

The total foot pounds were to be determined by tested pressure gages placed on the pumping and suction mains, to which was to be added the pressure due to the difference in the height of the gages. The total number of heat units was to be measured from the temperature of the feed-water taken at a point where it enters the boiler, to steam of the temperature shown by pressure gages on the boiler. An allowance of 3% was to be made for entrained water in the steam. All feed water was to be carefully weighed. All steam used in running the engines, or any part or appliance connected with the successful working of the same, was to be taken from the boilers to which the feed water was weighed. Condensed steam from the jackets was to be trapped and weighed during the whole time of the test. The feed-water was to be pumped to the boilers by a separate donkey pump, supplied with steam from another boiler. The test was to continue for 24 hours consecutively.

We find nothing in the specifications or in the correspondence which requires or guarantees that the above duty shall be made at the increased rate of delivery of 22,000,000 gallons per day.

In order to determine whether the pump would deliver 22,000,000 gallons of water per 24 hours and at the same time to determine the duty at this rate, a test was run at this higher speed. As the intake to the forebay was designed for 15,000,000 gallons, it was not considered advisable to run the test over the period of low tide, because of the danger of uncovering the end of the suction pipe. It was consequently agreed that the test should not last for 24 hours, but that it should begin as soon after low tide as possible, and that it should run until the river level once more became too low.

The engine was charged with the heat received by it, and credited with the heat rejected in feed and jacket water, and the feed and jacket water was weighed as prescribed by the specifications. To determine whether the duty as called for in the original specifications was obtained a test was run at the speed therein required. This test was continued for 10 hours. The amount of water pumped was to be computed by weir measurement, or by plunger displacement, making due allowance for slip, as the Chief of the Bureau of Water should determine. There was a weir at the Wentz Farm reservoir about 22,000 ft. away, but as the force main leading from the pump to the weir was provided with numerous connections with other pipes, to prevent any question being raised as to the tightness of the pipe and valves, a Venturi meter was placed in the main near the pump, and the capacity was determined by this meter.

The following are the principal dimensions of the engine:

Nominal Dimensions of Engine.

	Diameter, ins.	Mean area, sq. ins.
High-pressure piston	44	1,500.9
Low-pressure piston	88	6,062.5
Piston rods (2 for each piston)	5	.....
Plunger	28	.....
Stroke of piston and plungers	3.5 ft.	.....

Measured Dimensions of Pumps.

	Circumference, ins.	Mean area, sq. ins.
High-pressure plunger	88	604.37
Low-pressure plunger	88	604.37
	Diameter, ins.	Stroke, ins.
High-pressure plunger rod	5½	42 3-32
Low-pressure plunger rod	5½	41 63-64

Total plunger displacement per revolution of engine .....58.81 cu. ft. = 439.95 galls.

The high-speed test began at noon on June 16, 1897. At 7:58 p. m., a lead joint in a pipe connecting the force main with the No. 2 engine blew out, and necessitated the sudden stoppage of the test about one hour before it would have been stopped by the fall of the tide. The slow speed test began at 6:45 p. m., on June 18, and ended at 4:45 a. m., on June 19, 1897.

The following are the records of the test, the first being the data relating to the 22,000,000-gallon test and the second the data relating to the 15,000,000-gallon test. The horse power was determined from a few cards taken during the test:

High-Speed Test.

Time of Test, from noon until 7.58 p. m., June 16, 1897.
Water pressure by gage, lbs. per sq. in.....85.85
Suction by gage, lbs. per sq. in.....1.22
Pressure due to the difference in the height of gages, lbs. per sq. in.....10.16
Total water pressure, lbs. per sq. in.....94.79
Corresponding total head, ft.....219.16
Plunger displacement per revolution, cu. ft.....58.81
Total revolutions in 7 hrs. 45 mins.....15,846
Total revolutions per 24 hours.....56,141
Gallons per 24 hrs. by plunger displacment...24,699,233
Weir for Actuating Water:
Width of weir in ft.....1
Average height of water in ins.....4.49
Width of trough in ins.....21 9-16
Depth of trough below crest of weir in ins.....14
Water discharged per 24 hours in gallons.....455,650
Net gallons of water delivered to force main.24,243,583
Foot pounds of work per 24 hrs. on this basis.....44,236,000,000
Water pumped into boiler in 7 hrs. 58 mins., lbs.130,622
Amount of water required to bring the level of water in the boilers at the end of the test to the level at beginning, lbs.....1,530
Water fed to boiler per 24 hrs, lbs.....388,896
Water from separator per 24 hours, lbs.....2,868
Steam used by engine per 24 hours, lbs.....386,028
Steam pressure at engine gage, lbs. per sq. in...101.5
Steam pressure at boiler gage, lbs. per sq. in....104.2
Barometer, lbs. per sq. in.....14.6
Heat units per pound of steam, measured from 32°.....1,185.2
Heat units used by engine per 24 hours.....457,520,986
Water for intermediate separator, lbs. per 24 hrs...3,473
Temperature of water from intermediate separator..241.5°
Water from high pressure and reheater jackets, lbs. per sq. in.....29,723
Temperature of water from high pressure and reheater jackets.....335.2°
Water from low-pressure jackets, lbs. per 24 hrs..2,521
Temperature of water from low-pressure jacket.280.5°
Temperature of feed.....138.3°
Heat units restored per 24 hours.....47,761,200
Heat units chargeable to engine per 24 hrs.409,759,186
Duty: Foot pounds per million heat units on plunger displacement, making an allowance of 3% for entrained water in the steam, as called for by specifications.....111,294,940
Venturi Meter:
Diameter of body, ins.....48
Diameter of throat, ins.....18
Difference of pressures in feet of water.....7,144
Velocity through throat, feet per second, maker's rating.....21.15
Gallons per 24 hours.... ×.....24,156,000
Duty on this basis, foot pounds.....110,900,000
Apparent slip, per cent.....0.36
Weir at Reservoir:
Width of weir in feet.....8.015
Average height of water in feet.....1.229
Width of trough.....11 ft. 11½ ins.
Depth of trough below crest of weir.....2 ft. 5 ins.
Head due to velocity of approach.....0.01 in.
Water per 24 hrs. pumped into reservoir, gallons.....23,048,000
Apparent loss between Venturi meter and reservoir, gallons.....1,108,000
Apparent loss between Venturi meter and reservoir, per cent.....4.6
Miscellaneous Data:
Revolutions per minute.....39
Excess of capacity requirement of original specifications.....61.6%
Excess of capacity requirement guaranteed by contractor.....10.2%
Piston speed per minute.....273 ft.
Indicated horse power, steam cylinders.....969.7
Indicated horse power, water cylinder.....948.1
Steam pressure in receiver, lbs.....12.2
Vacuum, ins.....25.4
Steam pressure in high-pressure jacket and reheater jackets.....Boiler pressure
Steam pressure in low-pressure jackets, lbs.....47

Slow Speed Test.

Time of Test: From 6:45 p. m., June 18, to 4:45 a. m., June 19, 1897.
Water pressure by gage, lbs. per sq. in.....111.83
Suction by gage, lbs. per sq. in.....1.01
Pressure due to difference in the height of the gages, lbs.....9.67
Total water pressure, lbs. per sq. in.....120.49
Corresponding total head, ft.....278.54
Plunger displacement per revolution of engine, cu. ft.58.81
Total revolutions in 10 hours.....15,846
Total revolutions per 24 hours.....38,030
Gallons per 24 hours by plunger displacement.16,731,747
Weir for Actuating Water:
Width of weir, ft.....1
Average height of water, ins.....4.08
Water discharged per 24 hours, gallons.....397,670
Net gallons of water delivered to force main.16,333,804
Foot pounds of work done per 24 hrs. on this basis.....37,885,500,000
Water pumped into boilers in 10 hours.....136,790
Water pumped into boilers per 24 hours, lbs....328,296
Water from separator per 24 hours, lbs.....3,374
Steam used by engine per 24 hours, lbs.....324,922
Steam pressure at engine gage, lbs. per sq. in....102.3
Steam pressure at boilers, lbs. per sq. in.....104.3
Barometer, lbs. per sq. in.....14.7
Heat units per pound of steam.....1,185.4
Heat units used by engine in 24 hours.....385,162,539
Water from intermediate separator, lbs. per 24 hours.....5,530
Temperature of water from intermediate separator.....246.5°
Water from high-pressure and reheater jackets, lbs. per 24 hours.....24,270
Temperature of water from high-pressure and reheater jackets.....335.5°
Water from low-pressure jackets, lbs. per 24 hrs. 2,364
Temperature of water from low-pressure jackets.286.2°
Temperature of feed.....137.2°
Heat units restored per 24 hours.....39,883,874
Heat units chargeable to engine in 24 hrs...345,278,665
Duty: Foot pounds per million heat units on plunger displacement, making an allowance of 3% for entrained water in the steam, as called for by specifications.....113,118,000
Venturi Meter:
Diameter of body, ins.....48
Diameter of throat, ins.....18
Difference of pressure in feet of water.....3.107
Velocity through throat, feet per second, maker's rating.....14.00
Gallons per 24 hours.....15,900,000
Duty on this basis, foot pounds.....110,740,000
Apparent slip, per cent.....2.05
Weir at Reservoir:
Width of weir in feet.....8.013
Average height of water in feet.....0.000
Width of trough.....11 ft. 11½ ins.
Depth of trough below crest of weir.....2 ft. 5 ins.
Head due to velocity of approach.....0.005 ft.
Water per 24 hours pumped into reservoir, gallons.....14,276,000
Apparent loss between Venturi meter and reservoir, gallons*.....1,714,000
Apparent loss between Venturi meter and reservoir 10.7%
Miscellaneous Data:
Revolutions per minute.....26.41
Including water taken off by 12-in. main on Torresdale Ave.....6.6%
Excess of capacity requirement of specifications.
Piston speed per minute, feet.....184.9
Indicated horse power, steam cylinders.....846.4
Indicated horse power, water cylinders.....822.1
Steam pressure in receivers, lbs. per sq. in.....13.6
Vacuum inches.....24.7
Steam pressure in high-pressure jacket..Boiler pressure
Steam pressure in low-pressure jacket, lbs. per sq. in. 47

*Including water taken off by 12-in. main on Torresdale Ave.

During both tests the engine ran smoothly and steadily, without undue heating or vibration, above the contract rate of delivery. In conclusion, therefore, we report that it has more than fulfilled the requirements of the specifications and the guarantee of the contractor.

A NEW RECORDING THERMOMETER FOR MEASURING TEMPERATURES IN ENCLOSED SPACES.

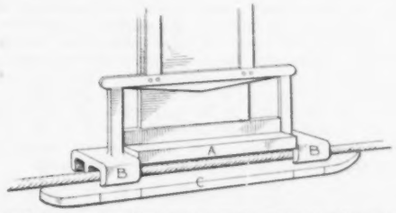
We illustrate herewith a thermometer designed for atmospheric ranges of temperature which can be applied to air, gases or liquids in a closed pipe or room. The complete instrument consists of a Bristol recording pressure gage in which the helical tube is completely filled with an expansible liquid. This tube coils and uncoils through a small range when subjected to changes of temperature, causing the movement of the arm which carries the recording pen, and is enclosed in the cylinder projecting from the back of the case of the recorder, as shown by the illustration. This cylinder protects the sensitive tube, and has a screw thread so that it may be passed through a gas main, the side of a tank or the partition of a room, as may be required. The operative part of the thermometer is thus entirely protected from any action of the gases or liquids of which the temperature is being recorded, and the operation of the instrument is independent of the pressure or vacuum within the closed space. These thermometers have been in successful operation for several months, and are manufactured by the Bristol Co., of Waterbury, Conn.

A Recording Thermometer for Measuring Temperatures Inside of Pipes, Tanks and Similar Enclosed Spaces.

The Bristol Co., Waterbury, Conn.

A CABLE CAR GRIP DESIGNED TO REDUCE SPEED ON CURVES.

A cable car grip designed to allow a reduction of speed without losing hold of the cable when passing around sharp curves, is being applied to the cars running on the Broadway line of the Metropolitan Traction Co., of New York city. At a number of points on this line there are very sharp curves, one of which particularly, a sharp reverse curve at Union Square, has gained the sobriquet of "dead man's curve," on account of the numerous accidents which have occurred in passing around it. The chief danger of these curves has been in passing around them at the full speed of the cable, which was necessitated by the fact that if the grips were loosened the cable slipped sideways from between the jaws, and the car was stalled on the curve. To correct the trouble Mr. F. S. Pearson, Chief Engineer of the Metropolitan Traction Co., designed the grip shown by the accompanying sketch. The under jaw of the old grip C was lengthened somewhat, and to the upper jaw was added the part B, which serves to keep the cable between the jaws A and C, even when they are loosened, so as to allow the cable to slide.



A Cable Car Grip Designed to Reduce Speed on Curves.

This addition to the upper jaw is made of Harveyized steel, as it is obviously subjected to considerable wear. In the first installation an entirely new lower jaw had to be added to the grip, but in future renewals it will be only the attachment to the upper jaw that will count, as the wear on other parts will not be increased. One point of the drawing, perhaps, needs some explanation. There being an emergency cable in the conduit for use in case of accident, it was necessary that the guide B should be of such construction that it could handle either cable, and it was, therefore, made with two grooves, as shown, one for the right hand and one for the left hand cable. It is stated that the actual expense of making the change which is described is about $20 per car. The new grip has been in operation for some time and has proved a decided improvement in the easy riding of the cars around curves.

BOOK REVIEWS.

THE CALCULUS FOR ENGINEERS.—By John Perry, M. E., D. Sc., F. R. S., Professor of Mechanics and Mathematics in the Royal College of Science, London, etc. London and New York: Edward Arnold. 12mo.; cloth; pp. 378; $2.50.

The preface of this book informs us that it describes what has for many years been the most important part of the regular course in the calculus for mechanical and electrical engineering students of the Finsbury Technical College. The author says:

> The students in October knew only the most elementary mathematics, many of them did not know the binomial theorem or the definition of the sine of an angle. In July they had not only done the work of the book, but their knowledge was of a practical kind, ready for use in any such engineering problems as I give here. * * * Many people think the subject one which cannot be taught in this elementary fashion, but Lord Kelvin showed me long ago that there is no useful mathematical weapon which an engineer may not learn to use. A man learns to use the calculus as he learns to use the chisel or the file on actual concrete bits of work, and it is on this idea that I act in teaching the use of the calculus to engineers.

A book of the kind of the one before us has long been needed. It is a fault of the ordinary mathematical training given by most schools that it uses calculus only as a mental discipline and that the student proceeds to forget it as soon as possible after graduation. As the author says, "such men hurriedly skip in reading a book when they see a sign of integration." The author's method is to lead up to the calculus by plotting on "squared paper" curves of several equations, discussing the "slope" of the lines, or the rates of increase of y relatively to the increase of x, and showing that this rate is the differential coefficient. By numerous examples and problems he enforces on the mind of the student such fundamental conceptions as

limiting values, velocity, acceleration, etc., expressed in the symbols of the calculus, and gradually develops just enough of the calculus to solve most of the mathematical problems of engineering in which calculus may be used as a handy tool. The book is divided into three chapters. The first two are headed respectively "x n" and "e x and sin x," and are devoted chiefly to the explanation and solution of practical engineering problems, including problems in strength of materials, steam and gas engines, electrical currents, etc., all of which are developed from the differentiation and integration of equations of the three general forms only, viz., algebraic, logarithmic and harmonic functions. In these chapters the student will learn a great deal about mechanics and engineering, and about how to apply the calculus to such problems, but little about the science of calculus itself as commonly understood and treated in the text books. In the third chapter, headed "Academic Exercises," are given in condensed form, the matter found in the ordinary treatises. In the introduction to this chapter the author says:

By means of a few rules it is easy to become able to differentiate any algebraic function of x, and in spite of our wish that students should read the regular treatises we are weak enough to give these rules here. They are mainly used to enable schoolboys to prepare for examination and attain facility in differentation. These boys so seldom learn more of this wonderful subject, and so rapidly lose the facility in question, because they have never learned really what dy-dx means, that we are apt with beginners to discourage much practice in differentation, and so err, possibly, as much as the older teachers, but in another way.

The style of the author is an unusual one for a mathematical treatise. It may be termed the "colloquial style," and is such as might be used by a teacher in talking freely to his class, interjecting some odd expressions now and then and occasionally a little humor. Here is an exampie under the discussion of "limits:"

Some people have the notion that we are stating something that is only approximately true; it is often because their teacher will say such things as "reject 16.1 dt because it is small," or "let dt be an infinitely small amount of time," and they proceed to divide something by it, showing that although they may reach the age of Methusaleh they will never have the common sense of an engineer."

The definition of the word "mass," which has been a subject of much controversy lately, is given in large black type as follows: "The weight of the body in pounds at London, divided by 32.2" and in a foot-note, the author says:

I have given elsewhere my reasons for using in books intended for engineers the units of force employed by all practical engineers. * * * One might as well talk Choctaw in the shops as speak about what some people call the English system, as if a system can be English which speaks of so many poundals of force and so many foot-poundals of work. * * I venture to say that there is not one practical engineer in this country who thinks in poundals, although all the books have used these units for 30 years.

We commend the author for his defining "mass" in the good, old-fashioned way, and for his castigation of the recent term "poundal," but we think he has himself made some verbal slips which are open to similar criticism. Thus he says: "Force in pounds is the space-rate at which work in foot-pounds is done." "Space-rate" may be Choctaw, it is surely not engineer's English. Also, "remember that when in mathematics we say sin x, x is supposed to be in radians. Some practising engineers may remember that their text books mentioned "radians," but we venture to say that they do not think in radians, and if a mathematician writing for engineers uses the term sin x, the engineers will understand that x is a certain angle measured in degrees, unless otherwise distinctly specified. The author seems to have a very bad case of "radians," for on p. 176 he says:

It is unfortunate that such books (of mathematical tables) are arranged either for the use of very ignorant or else for very learned persons, and so it is not quite easy to convert radians into degrees, or vice versa.

As books of mathematical tables are in constant use by engineers and others of every degree of learning and ignorance it would appear that if there had been any great need for the use of radians in such tables it would long ago have been supplied.

Another case of the mathematician's notation differing from the engineer's is the following: "When a mathematician writes log. x he always means the Napierian logarithm of x." When an engineer uses the Napierian logorithms he usually writes hyp. log. or log$_e$, and when he writes log. x he means the common logarithm of x.

The book is well printed, full-faced type being used to call attention to important statements. We recommend it not only for students but for the practising engineer who wishes to "brush up" his knowledge of calculus.

THE ARMOR PLATE CONTROVERSY continues. Secretary of the Navy Long has appointed Commodore John A. Howell and Captain A. H. McCormick as two members of the board authorized by the late Congress to report upon a government armor plant. Meanwhile the Secretary has rejected the offers of the armor-making companies to supply the armor for the three battleships now building, at a price to be hereafter fixed by the Navy Department. Mr. Long says it will be possible to go on with these ships, and fix the armor upon them later. In regard to European prices for armor, the Navy Department finds that Italy paid the highest price in 1896 for plates, or $600 per ton. In the same year the Bethlehem and Carnegie companies received $575 per ton for nickel steel, Harveyized plates, as compared with $650 in 1893. Dillenjer, a German maker, supplied Russia with Harveyized plates, in 1896, for about $530 per ton, and Krupp obtains about as much. The Bethlehem contract with Russia for armor plate was at $525 per ton. All contracts for armor plate in 1896, among foreign makers, exceeded $450 per ton. Le Creusot, the French establishment, in 1895, sold nickel-steel, Harveyized armor, for $475 per ton.

FIRE-PROOF WOOD FOR WARSHIPS has been more or less discussed since the Chinese-Japanese war proved the necessity for some such material. The Ordnance Bureau of the U. S. Navy Department has been making some recent tests of treated wood for boxes for fixed ammunition. The Chief of the Bureau reports that the wood loses strength by the chemical treatment; is difficult to work; corrodes brass, absorbs moisture, and refused to take paint. A further thorough investigation is to be made, but the expected results are very doubtful, and it is said that existing contracts for such wood will have to be cancelled. At the late Congress of Naval Architects, in England, Charles E. Ellis stated that the process of making wood incombustible increased the weight from 8 to 15%, and said that it is costly. A series of experiments have also been ordered by the British Admiralty. In our own navy the gunboat "Helena" and the battleship "Iowa" are fitted with fire-proof wooden decks, and these are being watched closely by the naval authorities.

THE NEW BROOKLYN TIMBER DRY-DOCK, now under repairs, may cost more than the $100,000 appropriated by Congress for remedying structural defects. A large coffer-dam is now being built across the entrance to the docks, where the chief leaks were located. Quicksand is now giving the engineers trouble at this point, and the character of the pile-driving indicates that more money may be required than was set aside for this purpose.

THE SALVAGE FOR THE STEAMSHIP "ST. PAUL," which went ashore at Long Branch on Jan. 25, 1896, has been fixed at $160,000 by the United States District Court in the decision of Judge Addison Brown in the libel against the steamship company entered by the Merritt Wrecking Co., the Chapman Derrick Co., and the North American Insurance Co. of Philadelphia. The cargo, valued at $1,980,989, mostly in gold coin and bars, was taken to New York by the wrecking and insurance companies. The steamer, valued at $2,650,000, was hauled off by the tugs of the same companies, on Feb. 4, uninjured. Of the amount awarded, $28,724.35 is charged against the cargo, and the remainder against the ship and owners.

THE PHILADELPHIA TRANSATLANTIC LINE is a new corporation owning three steamships, sailing every ten days from Philadelphia for London. The steamers are 5,000 and 6,200-ton vessels, and the line is the virtual successor of the Trident Line, once operated by Charles M. Taylor, in connection with the Philadelphia & Reading Railway Company, before that company went into the hands of a receiver.

EXPORTS OF ELECTRICAL MACHINERY are on the increase to Europe as well as to South America and Japan. It is reported that hardly a steamer sails without large consignments of electrical and mechanical apparatus. Those for June are given as particularly large. Telephones are in great demand in all directions due to their general excellence and low prices since the Bell monopoly expired, and two companies are recently reported as shippers of $25,000 worth. Venezuela and Rio de Janeiro have within a short time placed numbers of orders. One steamer for these ports sailing a short time ago took over 1,300 packages of electrical goods.

THE END OF THE TROLLEY MONOPOLY is assured by the decision of the United States Court of Appeals, rendered July 22, and now independent companies will be able to manufacture and install trolley plants without paying royalties. This decision is the outcome of a suit brought by the General Electric Co. against the Hoosick Ry. Co., which company was using a form of trolley developed by the Walker Co., of Cleveland, O. The General Electric Co. based their claims on a patent on the trolley wheel issued to Chas. Van Depoole in 1893. This patent has been upheld by various courts until there was such a feeling of certainty, that companies using other than General Electric apparatus were paying royalties to the extent of $100 per car. The defense claimed that the 1893 patent was invalid, owing to the same device being described in a previous patent dated 1890. This view was taken by the court. The outcome of this suit will no doubt give a stimulus to trolley building by removing all uncertainty and permitting competition.

A CELEBRATION OF THE INVENTION of the electric motor car was held July 26, at Eliot, Me., in connection with the summer meeting of the American Institute of Electrical Engineers, held July 26, 27 and 28 at that place. The celebration was in honor of Moses G. Farmer, who, on July 26, 1847, exhibited in Dover, N. H., what is considered to be the first electric car, and it was held in a portion of Eliot known as Greenacre-on-the-Piscataqua. It may be interesting to state that this place itself is a monument to the memory of Mr. Farmer, established by his daughter, Miss S. J. Farmer, to carry out an early formed plan of her father to locate at Greenacre, a summer school where those famous in the field of learning could meet and exchange ideas. The exercises included an interesting exhibit of early apparatus and addresses by the following prominent men: Prof. Cyrus F. Blackett, LL.D., Princeton University; Prof. A. G. Dolbear, Ph. D., of Tufts College; Prof. George F. Barker, LL.D., of the University of Pennsylvania; Louis Duncan, Ph. D., John Hopkins University, Baltimore; Prof. Michael S. Pupin, Ph. D., Columbia University, New York, and others.

WEATHER TABLE FOR JUNE, 1897. (Furnished to Engineering News by the Department of Agriculture.)

	Stations.	Temperature. (Degrees Fahrenheit.)				Wind.			Precipitation—rain or melted snow—inches.		
						Velocity in miles per hour.		Direction at time of max. velocity.			
		Average.	Max.	Min.	Range.	Average	Max.		Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	57.4	86	36	50	8.3	32	N	3.77	1.58	10
	Portland, Me.	58.2	83	44	39	6.8	27	NW	4.97	2.11	13
	New York City	65.2	86	48	38	12.6	53	NW	2.98	1.72	9
	Pittsburg, Pa.	67.9	88	42	46	5.5	30	SE	2.97	1.38	11
	Chicago, Ill.	65.1	93	44	49	15.1	55	S	3.60	2.01	14
	Omaha, Neb.	72.2	98	47	51	8.6	29	SE	1.43	.52	11
	St. Paul, Minn.	64.2	94	37	57	6 8	40	NW	8.18	2.51	14
	Duluth, Minn.	54.2	87	33	54	8.8	38	NE	3.48	1.35	13
	Bismarck, N. Dak.	62.8	95	33	62	9.3	41	S E	3.44	1.17	12
	Average.										
Southern Cities.	Washington, D. C.	69.6	93	43	50	6.4	25	NW	2.60	1.25	11
	Louisville, Ky.	74.2	16	51	45	7.4	44	NW	3.50	.90	12
	St Louis, Mo.	75.2	96	51	45	8.7	38	W	5.32	1.62	13
	Savannah, Ga.	81.8	100	61	39	7.1	40	NW	3.94	1.83	15
	Kansas City, Mo.	75.1	97	48	49	8.5	29	NW	7.09	4 37	12
	Jacksonville, Fla.	83.4	99	68	31	7.2	36	NW	5.01	1.93	12
	Chattanooga, Tenn.	77.4	96	54	42	6.2	44	SW	1.03	.37	8
	New Orleans, La.	81 8	98	69	29	6.7	24	SE	4.82	1 82	11
	Memphis, Tenn.	78.2	95	57	38	8.0	46	NW	2.50	.95	9
	Palestine, Tex.	79.4	98	59	39	6.1	40	NW	4.16	1.64	12
	Average.										
Western Cities.	Helena, Mont.	58.8	89	37	52	7.7	50	SW	3.66	.76	16
	Port Angeles, Wash.	54.6	70	38	32	7.5	32	SW	1.16	.63	9
	San Francisco, Cal.	58.9	83	48	35	13.5	39	W	.22	.19	3
	Salt Lake City, Utah.	66.0	92	42	50	6.5	31	W	.52	.38	6
	Santa Fe, N. Mex.	64.2	84	40	44	7.3	40	SW	.57	.22	8
	Denver, Colo.	65.2	90	40	50	7.9	60	SE	2.16	1.06	10
	Yuma, Ariz	83.0	106	56	50	—	33	NW	—	—	—
	Average.										